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Development of HATREMS Data Base and Emission Inventory Evaluation

Midwest Research Inst, Kansas City, Mo

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April 1977

DEVELOPMENT OF HATREMS DATA BASE AND EMISSION INVENTORY EVALUATION

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16. ABSTRACT

This report presents the results of an extensive data collection and analysis program which was conducted to (a) develop an emission factor data base for HATREMS; (b) prepare this data for loading into HATREMS; and (c) evaluate emission inventory information from HATREMS. HATREMS is a computerized subsystem of EPA's AEROS. HATREMS stores and reports source and emission data for noncriteria pollutants in a manner parallel to NEDS which stores and reports data for the five criteria pollutants.

Three hazardous pollutants (lead, fluorides, and HCl/chlorine) were selected from a list of nine pollutants for incorporation as separate chapters into "Emission Factors for Trace Substances" (EPA-450/2-73-001). These special report chapters are included as appendices to this report.

Point source data were developed/coded for 26 pollutants; area source data for 22 pollutants; and "free" area source data for 4 pollutants. Although the HATREMS data base was not processed through the computer system as part of this study, methodology was developed for evaluation of the emission inventory information to be generated from HATREMS. Finally, lead was evaluated for use in the EHIS, another subsystem of NEDS.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS		b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Emission factors	Chlorine		
Trace pollutants	Data system		
Hazardous pollutants	Emission inventory		
Lead	Point sources		
Fluoride	Area sources		

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Descriptors: *Pesticides, *Utilization, Insecticides, Herbicides, Fungicides, Policies, Production, Inventories.

Contents:
Production and use of pesticides;
Use patterns and application of pesticides;
Analysis of the public concern for reducing pesticide use.

PB-229 [illegible] PC[illegible]/MF$1.45
[illegible]
[illegible] THE ENVIRONMENT.
[illegible]
[illegible] Beatrice H. Holmes, and William A. [illegible] 1971, [illegible]
Paper copy available from GPO [illegible]

Descriptors: *Pesticides, *Law(Jurisprudence), [illegible] government, State government, International law, Government policies, Legislation, Pollution.

The existing legal framework for controlling the release of pesticides into the environment consists of Federal laws and operative orders, State laws and institutional mechanisms, international law and institutional mechanisms, and the inter- and intra-agency organizations devised by Federal agencies for the purpose of coordinating pest control responsibilities.

PB-230 [illegible] PC$7.25/MF$1.45
National Field Investigations Center-Denver, Colo.
REMOTE SENSING REPORT, MAJOR WATERWAYS, MEMPHIS, TENNESSEE VICINITY.
Apr 72, 62p

Descriptors: *Water pollution, *Remote sensing, *Outfall sewers, *Waterways(Watercourses), Infrared detection, Near ultraviolet radiation, Infrared reconnaissance, Visible spectrum, Photographic techniques, Maps, Tennessee.
Identifiers: *Memphis(Tennessee).

An aerial reconnaissance mission was carried out over selected waterways in the Memphis, TN vicinity on the 7th of January, 1972. A Remote Sensing Report was issued covering this mission. The expressed purpose of the reconnaissance mission was to provide the following capabilities: Apprise the ground survey team of the current status of the suspected outfalls detected in the imagery from the first reconnaissance mission, and to locate any industrial or public outfalls that were not detected in the imagery from the previous mission.

PB-230 [illegible] PC$7.75/MF$1.45
Pennsylvania State Univ., University Park. Inst. for Research on Land and Water Resources.
CRITERIA FOR ESTIMATING LIMITING NUTRIENTS IN NATURAL STREAMS.
Research publication no. [illegible],
James T. O'Shaughnessy and Archie J. McDonnell. Dec 71, [illegible]p W73-[illegible], OWRR-A-[illegible]-PA(2)
Contract DI-14-31-0001-4038

Descriptors: *Aquatic plants, *Algae, *Nutrients, *Absorption(Biology), Phosphorus, Nitrogen, Water pollution, Plant growth, Bioassay, Sediments.
Identifiers: *Limiting factors, *Eutrophication.

The aquatic macrophytes Elodea canadensis and Potamogeton crispus, [illegible] sp., and the algae [illegible] sp., [illegible], Oscillatoria sp., and Microspora sp. were tested for their ammonium nitrogen absorption rate, alkaline phosphatase enzyme activity, extractable surplus phosphorus content, and nitrogen and phosphorus tissue content. Comparisons of the nutritional level of the test species were made with corresponding levels of nitrogen and phosphorus monitored in streams [illegible] and from secondary sewage treatment plant effluent.

PB-230 [illegible] PC$[illegible]/MF$1.45
Environmental Protection Agency, Washington, D.C. Agricultural Pollution Control Research Program.
PROCEEDINGS OF THE 1973 CORNELL AGRICULTURAL WASTE MANAGEMENT CONFERENCE.
1973, [illegible]
Library of Congress Catalog No. 73-83460.

Descriptors: *Water pollution, *Agricultural wastes, *Meetings, *Solid waste disposal, Beef cattle, Poultry, Livestock, Legislation, Regulations, Fertilizers, Waste disposal, Composts, Feedlots, Wastes, Residues, Swine, Surface water runoff, Waste treatment, Agricultural [illegible].
Identifiers: Manure, *Poultry wastes.

The report on the 1973 conference covers research on agriculture waste management. Included are topics on: Agricultural pollution control programs, livestock operations and waste management, beef cattle, poultry, and swine wastes, feedlot wastes, dairy manure waste handling systems, land disposal of residues, and automated handling of swine wastes.

PB-230 [illegible] PC$[illegible]/MF$1.45
General Dynamics, San Diego, Calif. Convair Aerospace Div.
REMOTE SENSING OF AIR POLLUTION IN URBAN AREAS.
Environmental protection technology series,
[illegible] Ludwig. Aug 73, [illegible]p
EPA-650/2-73-[illegible]
Contract EPA-68-02-[illegible]
See also PB-221 075.

Descriptors: *Air pollution, *Remote sensing, Urban areas, Sulfur dioxide, Ozone, Hydrocarbons, Carbon monoxide, Concentration(composition), Exhaust gases, Spectrometers, Interferometers, Spectrum analysis, Steel plants.
Identifiers: Remote optical sensing of emission, *Air pollution detection.

Remote sensing of air pollution was made using a scanning spectrometer ([illegible] system) and a Michelson interferometer. Both systems were for transmission measurements over nominal path lengths of one and two miles and for stack emission measurements. A comparison shows that the spectra of both instruments are of the same quality. A comparison of both instruments is made and the advantages and disadvantages are cited. In addition to the above measurements, the [illegible] system alone was used to measure the pollution from an extended source (oil refinery) over a path length of 1/4 mile. All of the spectra were analyzed and a number of pollutants were identified.

PB-230 [illegible] PC$[illegible]/MF$1.45
IIT Research Inst., Chicago, Ill.
DEVELOPMENT OF EMISSION FACTORS FOR ESTIMATING ATMOSPHERIC EMISSIONS FROM FOREST FIRES.
Final rept.,
George Yamate. Oct 73, [illegible]p* EPA-450/3-73-[illegible]
Contract EPA-68-02-[illegible]

Descriptors: *Forest fires, *Air pollution, Combustion products, Estimating, Sulfur oxides, Nitrogen oxides, Carbon monoxide, Hydrocarbons, Particles, Regions, Mathematical models, Residuals, Fuels, Estimates.
Identifiers: *Emission factors.

This report contains emission factors [illegible] are presented.

PB-230 [illegible] PC$[illegible]/MF$1.45
[illegible] Environmental Specialists, Inc., [illegible]
QUALITY CONTROL PRACTICES IN PROCESSING AIR POLLUTION SAMPLES.
George A. [illegible], Charles E. [illegible], Richard W. [illegible], and Robert J. Bryan. Mar 73, [illegible]p APTD-[illegible]
Contract EPA-68-02-[illegible]

Descriptors: *Air pollution, *Data processing, *Quality control, Sampling, Chemical analysis, Statistical analysis.

A quality control program is developed to minimize sources of variation inherent in all analytical and technical functions. Through the use of standard operating procedures and statistical techniques, [illegible] determinate errors are identified and controlled. The effects of random errors are measured and used to express the degree of confidence to be placed in the analytical data and to determine when the process that generates the data is not functioning properly. This document is intended to provide the administrator or supervisor with guidelines for establishing a detailed quality control program that is consistent with his specific needs and objectives.

PB-230 [illegible] PC$[illegible]/MF$1.45
GCA Corp., Bedford, Mass. GCA Technology Div.
STATE OF UTAH COMPILATION OF NEDS DATA.
[illegible] and N. [illegible] Dec 73, [illegible]p
GCA-TR-[illegible] EPA-450/3-74-[illegible]
Contract EPA-68-02-[illegible]

Descriptors: *Utah, *Air pollution, Carbon monoxide, Hydrocarbons, Nitrogen oxides, Sulfur dioxide, Particles, Tables(Data).
Identifiers: *National Emissions Data System, Air pollution sources, Emission factors, Air Quality Control Regions, Point sources.

The report describes the work performed in updating the National Emission Data System (NEDS) for Utah for the EPA. The point source data was obtained from the files of the Air Quality Section of the Utah State Division of Health. Sources with the potential to emit over [illegible] tons/year of any of the five major pollutants (particulates, sulfur dioxide, nitrogen oxides, hydrocarbons, and carbon monoxide) were included. The results of the emission inventory are summarized by region and source type, and county and source type. A map of Utah shows the Air Quality Control Regions and the counties. A general relative contribution from both area sources and point sources are given together with the principal contributor. Appendix A describes how to perform motor vehicle emission calculations.

PB-230 [illegible] PC$[illegible]/MF$1.45
Environmental Protection Agency, Research Triangle Park, N.C. Office of Air Quality Planning and Standards.
EMISSION FACTORS FOR TRACE SUBSTANCES.
Final rept.
David Anderson. Dec 73, [illegible]p* EPA-450/2-73-[illegible]

Descriptors: *Pesticides, *Utilization, Insecticides, Herbicides, Fungicides, Patterns, Production, Inventories

Contents:
Production and use of pesticides;
Use patterns and application of pesticides;
Analysis of the means available for reducing pesticide use

PB-[illegible] PC[illegible]
Economic Research Service, Washington, D.C. [illegible]
[illegible] CONTROLLING THE RELEASE OF PESTICIDES INTO THE ENVIRONMENT.
Pesticide study series.
[illegible]
Paper copy available from GPO [illegible]

Descriptors: *Pesticides, *Law(Jurisprudence), National government, State government, International law, Government policies, Legislation, Pollution

The existing legal framework for controlling the release of pesticides into the environment consists of Federal laws and executive orders, State laws and institutional mechanisms, international law and institutional mechanisms, and the [illegible] and intra-agency organizations devised by Federal agencies for the purpose of coordinating pesticide responsibilities.

PB-[illegible] PC$[illegible]/MF$1.45
National Field Investigations Center-Denver, Colo.
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CRITERIA FOR ESTIMATING LIMITING NUTRIENTS IN NATURAL STREAMS.
Research publication no. [illegible]
[illegible] and [illegible] McDonnell. Dec 73, [illegible]p [illegible]
Contract [illegible]

Descriptors: *Aquatic plants, *Algae, *Nutrients, *Absorption(Biology), Phosphorus, Nitrogen, Water pollution, Plant growth, Bioassay, Sediments.
Identifiers: *Limiting factors, *Eutrophication.

The aquatic macrophytes Elodea canadensis and Potamogeton crispus, [illegible] and the algae Cladophora sp., [illegible] and Microspora sp. were tested for their ammonium nitrogen absorption rate, alkaline phosphatase enzyme activity, [illegible], surplus phosphorus content, and nitrogen and phosphorus tissue content. Comparisons of the nutritional level of the test species were made with corresponding levels of nitrogen and phosphorus monitored in stream water, absorbed on stream sediments, and in the interstitial water of the sediments. [illegible] discharges from secondary sewage treatment plant effluents.

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Environmental Protection Agency, Washington, D.C. Agricultural Pollution Control Research Program.
PROCEEDINGS OF THE 1973 CORNELL AGRICULTURAL WASTE MANAGEMENT CONFERENCE.
1973, [illegible]
Library of Congress Catalog No. 72-[illegible]

Descriptors: *Water pollution, *Agricultural wastes, *Meetings, Solid waste disposal, Beef cattle, Poultry, Livestock, Irrigation, Regulations, Pyrolysis, Waste disposal, Composts, [illegible], Wastes, Residues, Swine, Surface water runoff, Waste treatment, Agricultural economics.
Identifiers: Manure, *Feedlot wastes.

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Contract EPA-68-02-[illegible]
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Final rept.
George Yamate. Oct 73, 147p* EPA-450/3-73-009
Contract EPA-68-02-[illegible]

Descriptors: *Forest fires, *Air pollution, Combustion products, Estimating, Sulfur oxides, Nitrogen oxides, Carbon monoxide, Hydrocarbons, Particles, Regions, Mathematical models, Pyrolysis, Vegetation, Estimates.
Identifiers: *Emission factors.

This report contains emission factors (weight of pollutant per unit burned) for estimating atmospheric emissions from forest fires [illegible] for each of the [illegible] U.S. Forest Service regions [illegible]. The pollutants considered are total particulates, hydrocarbons, carbon monoxide, nitrogen oxides, and sulfur oxides. Data on acreage consumed by wildfires are used with the factors to estimate mass emissions for each region. The effects of such variables as terrain, density of vegetation coverage, type of vegetation, wind speed and humidity are also discussed. Proposed approaches to mathematically correlate these variables via empirical and theoretical models, with both emission factors and mass emissions are presented.

PB-[illegible] PC$[illegible]/MF$1.45
[illegible] Environmental Specialists, Inc., [illegible]
QUALITY CONTROL PRACTICES IN PROCESSING AIR POLLUTION SAMPLES.
[illegible] and [illegible] Bryan. Mar 73, [illegible]p APTD-[illegible]
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[illegible] Martin, and [illegible] Dec 73, [illegible]p
GCA-TR-[illegible] EPA-[illegible]
Contract EPA-68-02-[illegible]

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Identifiers: *National Emissions Data System, Air pollution sources, Emission factors, Air Quality Control Regions, Point sources.

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Environmental Protection Agency, Research Triangle Park, N.C. Office of Air Quality Planning and Standards.
EMISSION FACTORS FOR TRACE SUBSTANCES.
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David Anderson. Dec 73, [illegible]p* EPA-450/2-73-00

EPA-450/3-77-011

DEVELOPMENT OF HATREMS DATA BASE AND EMISSION INVENTORY EVALUATION

by

Christine M. Maxwell, Russel Bohn,
Roger Cuscino, and Chatten Cowherd, Jr.

Midwest Research Institute
425 Volker Boulevard
Kansas City, Missouri 64110

Contract No. 68-02-2300

EPA Project Officer: Jacob G. Summers

Prepared for

ENVIRONMENTAL PROTECTION AGENCY
Office of Air and Waste Management
Office of Air Quality Planning and Standards
Research Triangle Park, North Carolina 27711

April 1977

This report is issued by the Environmental Protection Agency to report technical data of interest to a limited number of readers. Copies are available free of charge to Federal employees, current contractors and grantees, and nonprofit organizations - in limited quantities - from the Library Services Office (MD-35), Research Triangle Park, North Carolina 27711; or, for a fee, from the National Technical Information Service, 5285 Port Royal Road, Springfield, Virginia 22161.

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Publication No. EPA-450/3-77-011

PREFACE

This report was prepared for the Environmental Protection Agency (EPA), Office of Air Quality Planning and Standards, under Contract No. 68-02-2190. Mr. Jacob Summers served as EPA project officer. The work was performed in the Environmental and Materials Sciences Division of Midwest Research Institute (MRI) under the supervision of Dr. Chatten Cowherd, Jr., Head, Air Quality Assessment Section.

Mrs. Christine Maxwell, Principal Investigator, was the main author of this report. She was assisted by Mr. Russel Bohn and Mr. Roger Calasse. Other MRI staff members who contributed to the program include Mr. Thomas Cuscino, Mr. Ralph Keller, and Mr. Leroy Frame.

Approved for:

MIDWEST RESEARCH INSTITUTE

L. J. Shannon, Director
Environmental and Materials
Sciences Division

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Special acknowledgment is made to Mr. David Anderson, EPA Region VIII, who compiled lead emission factor data and authored the original draft of the lead chapter (revised herein as Appendix B).

In addition, special thanks is due to Dr. Richard Reznik, Monsanto Research Corporation, who provided data for use in Task I.

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SUMMARY

This report presents the results of an extensive data collection and analysis program which was conducted to (a) develop an emission factor data base for HATREMS; (b) prepare this data for loading into HATREMS; and (c) evaluate emission inventory information from HATREMS. HATREMS (Hazardous and Trace Emission System) is a computerized subsystem of EPA's AEROS (Aerometric and Emission Reporting System). HATREMS stores and reports source and emissions data for noncriteria pollutants in a manner parallel to NEDS (National Emissions Data System) which stores and reports data for the five criteria pollutants.

The emission factor data base distinguishes between point, area, and "free" (non-NEDS) area sources. The data base consists of the following specific items:

Point Sources

Source Classification Code (SCC)
Pollutant Code
Emission Factor
Default Multiplier (e.g., pollutant content)
Multiplier Units
Control Efficiency Multiplier
NEDS Pollutant Flag
Action Code

Area Sources

Area Source Category (ASC)
Pollutant Code
Emission Factor
Default Multiplier
Multiplier Units
Action Code

"Free" Area Sources

State
County
Air Quality Control Region (AQCR)
Area Source Category (ASC)
Pollutant Code
Year of Record
Source Rate

Source Activity Factor
Emissions (tons/year)
Comments

Additional HATREMS data items include: data entered into HATREMS, emission factor origin, emission factor reliability and comments on assumptions in the emission factors.

Point source data were developed/coded for each of the following 26 pollutants:

- Ammonia
- Arsenic
- Asbestos
- Barium
- Beryllium
- Boron
- Cadmium
- Chlorinated Compounds
  - Chlorine
  - Hydrogen Chloride
- Chromium
- Copper
- Fluorinated Compounds
  - Fluorides
  - Hydrogen Fluoride
- Hydrogen Sulfide
- Lead
- Magnesium
- Manganese
- Mercury
- Molybdenum
- Nickel
- Phosphorus
- Selenium
- Silver
- Titanium
- Vanadium
- Zinc

In addition, area source data were developed/coded for all the above pollutants except ammonia, asbestos, hydrogen chloride, hydrogen fluoride, and hydrogen sulfide. Area source data were also developed/coded for polycyclic organic material. Finally, "free" area source data were developed for rubber tire wear, brake lining wear, and motor oil consumption. "Free" area source data were coded for asbestos, barium, cadmium, and zinc.

Three hazardous pollutants (lead, fluorides, and HCl/chlorine) were selected from a list of nine pollutants for incorporation as separate chapters into "Emission Factors for Trace Substances" (EPA-450/2-73-001). These special report chapters are included as appendices to this report.

Although the HATREMS data base was not processed through the computer system as part of this study, methodology was developed for evaluation of the emission inventory information to be generated from HATREMS. Finally, lead was evaluated for use in the Emission History Information System (EHIS), another subsystem of NEDS.

I. INTRODUCTION

This report presents the results of a program conducted by Midwest Research Institute (MRI) to develop an expanded hazardous and trace substance emissions data base and evaluate HATREMS emissions inventory information.

In this section, the background of the hazardous and trace emissions problem and the AEROS system are reviewed and the objectives of the overall program are stated.

A. Background

The environmental impact of hazardous and trace emissions generated by various sources has become a matter of increasing national concern. Strong correlations are indicated between ambient levels of toxic substances and adverse health effects. Clearly there is a need for assessment and control of hazardous and trace emissions in addition to the standard criteria pollutants.

To aid in the analysis of the causes and extent of air pollution in the United States, the Environmental Protection Agency (EPA), National Air Data Branch, has established the Aerometric and Emissions Reporting System (AEROS)--a comprehensive computer-based system designed to collect, store and analyze air pollution data. Subsystems of AEROS include:[1]

1. The National Emissions Data System (NEDS).
2. The Storage and Retrieval of Aerometric Data (SAROAD).
3. The Hazardous and Trace Substance Emissions System (HATREMS).
4. The Source Test Data System (SOTDAT).
5. The Emissions History Information System (EHIS).
6. The Weighted Sensitivity Analysis Program (WSAP).
7. The Source Inventory and Emission Factor Analysis Program (SIEFAP).
8. The Regional Emissions Projection System (REPS).

HATREMS inputs, stores, and reports source and emissions data for noncriteria pollutants in a manner closely parallel to NEDS which stores and reports data for the five criteria pollutants (i.e., carbon monoxide, particulates, sulfur dioxide, nitrogen oxides, and hydrocarbons). Data stored in NEDS includes (a) more than 135,000 point emission sources at 63,000 facilities and (b) area source records for every county within the United States.[1]

NEDS data (some of which is accessible to HATREMS) include:

1. Point Source Data

Source description - Name, address, types of source, year of record, comments.

Emissions data - Operating or production rate, estimated emissions, EPA calculated emissions, control device type and efficiency on each criteria pollutant.

Modeling parameters - UTM coordinates of source, stack height, and diameter, exhaust gas temperature, and flow rate.

Compliance information - Allowable emissions, applicable control regulations, compliance status, and schedules.

2. Area Source Data

Source description - Name and location of area (county) source, population, year of record.

Activity levels - Countywide activity level of each type of area source (e.g., tons of coal burned in all domestic space heating equipment in a county).

Emissions data - Emission estimates for the entire county (for each pollutant) as well as for each area source category.

B. Objectives

The principal objectives of the investigation reported herein were (a) to develop an expanded hazardous and trace substance emission factor data base, (b) to prepare this information for loading into EPA's HATREMS, and (c) to evaluate emission inventory information from HATREMS.

To accomplish the above objectives, the overall program was organized into eight major tasks:

Task I = Collect and Assess Available Data

Task II = Review Reference Reports

Task III = Code Emission Factor Data for NEDS SCC/HATREMS Categories

Task IV = Develop/Code Emission Factor Data for NEDS Area Source Categories

Task V = Develop/Code Emission Factor Data for "Free" Area Source Categories

Task IV = Keypunch and Verify Coded Data

Task VII = Evaluate HATREMS Emissions Inventories

Task VIII = Evaluate Use of NEDS Emissions History Information System

The remainder of this report is organized by task as follows:

- Section II presents a description of each program task.
- Section III presents the methodology used in Tasks I and II.
- Sections IV through IX present detailed descriptions of the methodology and results for Tasks III through VIII, respectively.
- Section X presents an overall discussion of the project, introduces example coded data for lead and introduces special report section write-ups for the selected hazardous pollutants--lead, fluorides and hydrogen chloride/chlorine. In addition, recommendations are presented for future work.

II. OVERALL TECHNICAL APPROACH

The overall technical approach for this program is diagrammed in Figure 1. The following paragraphs describe the objectives of each task. Subsequent chapters describe in detail the methodology used in accomplishing each task.

Task I (Section III) - The objective of this task was to select approximately three pollutants, from a list of nine, for inclusion in EPA Publication No. EPA-450/2-73-001, *Emission Factors for Trace Substances*. The nine pollutants considered in this task were:

1. Fluorides,
2. Polychlorinated biphenyls (PCBs),
3. Polycyclic organic material (POM),
4. Hydrogen fluoride,
5. H_2SO_4 and/or other sulfates,
6. Hydrogen chloride and chlorine,
7. Total reduced sulfur,
8. Fluorocarbons, and
9. Lead.

Task II (Section III) - The objective of this task was to review (a) reports provided by the EPA project officer for this study, and (b) miscellaneous reports specific to the pollutants listed in Task I. These data sources were subsequently used in Task I and Tasks III through V and are reported herein as a bibliography.

Task III (Section IV) - For this task, emission factor data were assessed for each reference in Task II, with the objective of coding point source emission factors and control efficiency factors for any pollutant with sufficient data.

Task IV (Section V) - The objective of Task IV was to develop and code emission factors for the NEDS Area Source Categories (ASC). These source categories include: fuel consumption, on-site incineration, open burning, air traffic, road vehicle traffic, construction and forest fires. References designated in Task II were used.

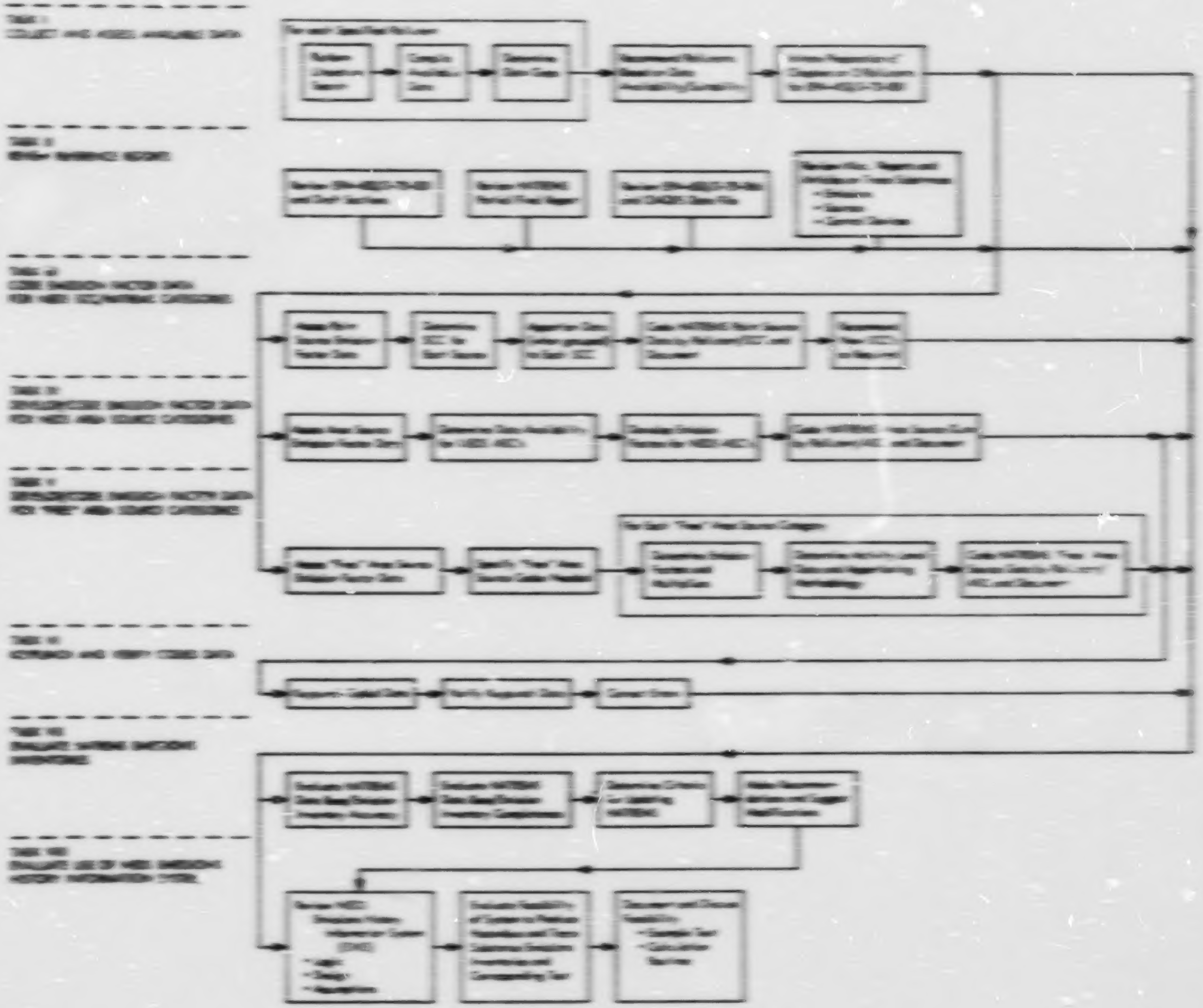

Figure 1 - Overall Project Task/Subtask Design

Task V (Section VI) - The objective of this task was to develop and code emission factors and activity levels for "free" area source categories. A "free" area source category is a category which (a) accounts for a significant quantity of emissions of some non-NEDS pollutant(s) and (b) is not presently included as an Area Source Category (ASC) in NEDS.

Task VI (Section VII) - This task consisted of the keypunching and verification of area and "free" area source data as coded under Tasks IV and V, respectively.

Task VII (Section VIII) - The objective of Task VII was to evaluate the HATREMS input data base and develop a procedure for evaluating HATREMS emissions inventories. This task reviews the overall program and provides suggestions for updating coded pollutant data.

Task VIII (Section IX) - The objective of this task was to evaluate the feasibility of using the NEDS Emissions History Information System (EHIS) to produce emissions inventories for hazardous and trace substance emissions. Example text and calculation routines were prepared for lead.

III. LITERATURE REVIEW AND SPECIAL POLLUTANT SELECTION

The general approach taken to accomplish Task I (Collect and Assess Available Data) and Task II (Review Reference Reports) was to (a) perform a comprehensive literature search and compile available reference material, and (b) determine pollutants suitable for inclusion in HATREMS and incorporation in EPA-450/3-73-001.[2]

The pollutants considered in the initial literature review were: fluorides, polychlorinated biphenyls, polycyclic organic material, hydrogen fluoride, H_2SO_4 and/or other sulfates, hydrogen chloride (and chlorine), total reduced sulfur, fluorocarbons and lead.

A. Literature Search

The literature search began with a preliminary review of documents supplied by the EPA project officer and a review of MRI in-house documents. A listing of the most pertinent references is presented in the bibliography. Because many of the documents on hand were written prior to 1973, a review of more recent literature sources was indicated and subsequently undertaken. Table 1 presents a summary of the major data sources reviewed. In addition, an effort was made to identify pre-1973 documents of significance which may not have been previously obtained.

TABLE 1

SUMMARY OF DATA SOURCES SEARCHED

Data Source	Dates Searched
Journal of the Air Pollution Control Association	1973 through August 1976
Environmental Science and Technology	1973 through August 1976
Atmospheric Environment	1973 through August 1976
Air/Water Pollution Report	February 1976 through August 1976
ORD Publications Summary	June 1975 through March 1976
Air Pollution Abstracts	1975 through August 1976
69th Annual Air Pollution Control Association Meeting	June 1976

During the early stages of this project, lead was tentatively selected as one of the pollutants to be included in EPA 450/2-73-001. An in-house search on lead was computer-generated from a literature file being compiled by MRI for the National Institutes of Health. Approximately 80 references related to lead in the atmosphere were found. In addition, an NTIS lead search was reviewed covering reports published and abstracted from 1964 to January 1976. Approximately 30 references related to emissions from stationary and mobile sources, as well as sampling and analysis methods, were determined to be relevant to this study.

B. Pollutant Selection Criteria

The intent of Task I was to perform an evaluation of the pollutants focusing on the availability of sufficient data to develop source-specific emission factors, incorporating control equipment type and efficiency.

Source emissions data can be reported in three forms: (a) concentration of pollutant emitted in units of parts per million by volume (or weight) or micrograms per cubic meter, (b) emission rate in units of weight per time (e.g., pounds per hour), and (c) emission factor in units of weight per quantity of material processed.

Emission factors (as well as application of control technology) are required input to HATREMS and may be calculated using concentration or emission rate data in conjunction with process throughput data. When data are reported in a variety of forms, or in different units, they are difficult, if not impossible, to compare within an industrial group.

The emission factors listed in the EPA Publication AP-42, "Compilation of Air Pollutant Emission Factors," were summarized for each of the nine pollutants. A review of all other compiled reference material was performed to determine data gaps.

In addition to data availability, the following factors were considered in judging the suitability of each pollutant:

1. Evidence of adverse health impacts.

2. Extent of measurement of emissions from major sources.

3. Reliability of sampling techniques and analysis methods.

4. Compatibility of the major emissions sources with the NEDS Source Classification Codes and Area Source Categories.

C. Pollutant Evaluation

Table 2 presents a summary of the evaluation of each pollutant. For each pollutant/criteria combination, a qualitative rating is given.

Table 2 was compiled on the basis of data sources found in the literature search or contained within the documents listed in the bibliography. The extent of the emission factor data was evaluated on the basis of (a) determination of whether the emissions data reported could be converted to uncontrolled emission factors and control efficiencies, and (b) the extent to which the major emissions sources of each pollutant were represented.

Assessment of the reliability of sampling and analysis methods were based on an evaluation by in-house personnel. MRI staff members were able to base their judgments of this criterion on (a) experience in collaborative testing of various emissions measurement techniques, including methods for sampling and analysis of sulfates, and (b) familiarity with potential pollutant sampling problems.

Assessment of adverse health impacts was based on an analysis of threshold limit values (in micrograms per cubic meter) and mass emission rates (in tons per year). Table 3 presents a ranking of relative health impact by pollutant--the higher the rank, the higher potential for adverse health effects.

The compatibility of the sources with Source Classification Codes and Area Source Categories were determined by a comparison of lists of each code type with the major emissions sources of each pollutant.

As indicated in Table 2, the extent of emission factor data for polychlorinated biphenyls, total reduced sulfur, and fluorocarbons is limited. Availability of data for the remaining six pollutants is rated fair to good.

Polycyclic organic material and H_2SO_4 and/or other sul[illegible] have unreliable source sampling methods which reduce the reliab[illegible] of emissions data for these pollutants. Analysis methods for a[illegible] didate pollutants have been rated fair or good.

Fluorocarbons do not have a direct health impact, alt[illegible] effective impact could be considered greater with the additional [illegible]tion of the indirect problem--long term atmospheric effects.

Finally, total reduced sulfur and fluorocarbons have [illegible] compatibility with existing Source Classification Codes and A[illegible] Categories.

TABLE 2

POLLUTANT EVALUATION

Pollutant	Extent of Emission Factor Data	Reliability of Sampling Methods	Reliability of Analysis Methods	Adverse Health Impacts	Data Compatibility With Source Codes
Fluorides	Good	Good	Good	Moderate	Fair
Polychlorinated biphenyls	Poor	Good	Fair	High	Fair
Polycyclic organic material	Fair	Poor	Fair	High	Good
Hydrogen fluoride	Good	Good	Good	Moderate	Good
H_2SO_4 and/or other sulfates	Fair	Poor	Good	Moderate	Good
Hydrogen chloride (and chlorine)	Fair	Good	Fair	Moderate to High	Good
Total reduced sulfur	Poor	Good	Good	Moderate	Poor
Fluorocarbon	Poor	Uncertain	Fair	Low to High[a]	Poor
Lead	Fair	Good	Good	High	Fair

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[a] Indirect effects.

TABLE 3

THRESHOLD LIMIT VALUES AND ATMOSPHERIC EMISSIONS BY POLLUTANT[a]

Pollutant	Threshold Limit Value-TLV (mg/m³)	Mass of Emissions (tons/year) Point Sources[b]	Total[c]	Mass ÷ TLV Point Sources	Total	Rank Point Sources	Total
Fluorides	2.5	21,000	163,250[d]	8,400	65,300	5	4
Polychlorinated biphenyls	-	-	-	-	-	-	-
Polycyclic organic material	0.001	20,500	4,764,115[d]	2.05 x 10^7	4.8 x 10^9	1	1
Hydrogen fluoride	2.0	14,400	-	7,200	-	6	-
H_2SO_4 and/or other sulfates	1.0 (as H_2SO_4)	57,600	-	57,600	-	3	-
Hydrogen chloride (and chlorine)	7.0 (as HCl) 3.0 (as Cl_2)	29,000 11,100	307,600[d] 678,700[d]	4,140 3,700	43,900 226,000	7	2
Total reduced sulfur	15.0 (as H_2S) 10.0 (as mercaptans)	308,000 64,300	- -	20,530 6,430	- -	4	-
Fluorocarbons	1,000	14,400	[illegible][d,e]	13	175	8	5
Lead	0.15	[illegible]	325,400[f]	[illegible]	2.17 x 10^6	2	3

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[a] From Reference 3 unless otherwise designated.

[b] Controlled emissions.

[c] Uncontrolled emissions.

[d] Based on Reference [illegible] and Bibliography Reference [illegible]; coal combustion included as chlorine.

[e] See Table 15.

Fluorocarbons and total reduced sulfur have low priority for inclusion in EPA 450/2-73-001 in comparison with the remaining pollutants. Fluorocarbons are rated poor in two areas. Total reduced sulfur is a nebulous pollutant which includes potentially hazardous as well as nonhazardous sulfur compounds with no distinction.

Hydrogen fluoride does not include as many sources of emissions as the *total fluoride* category, and thus the latter category may prove more useful in an emissions inventory.

Lead, *fluorides*, and *hydrogen chloride/chlorine* were selected for preparation of sections for inclusion in EPA 450/2-73-001 (reproduced herein as Appendices B, C, and D).

IV. POINT SOURCE EMISSION FACTOR DATA

Task III consisted of the development and coding of emission factor data for point sources based on the NEDS Source Classification Codes (SCCs). The following subsections: (a) list the point source data required in the HATREMS data base, and (b) describe the methodology and results of this task.

A. Data Requirements

The following point source data were designated for coding by NEDS SCC/HATREMS pollutant combination:

1. Emission factor;

2. Default emission factor multiplier;

3. Multiplier units;

4. Control efficiency multiplier;

5. NEDS pollutant flag; and

6. Action code.

An emission factor can be defined as the ratio of the rate of emissions to the process (or product) rate, or the quantity of emissions to the quantity of process material. In HATREMS, the emission factor is given in units of pounds per SCC unit times the pollutant content of the raw m[illegible]ial. The default emission factor multiplier, with appropriate multipli[illegible]its, provides the average pollutant content of the raw material. If the pollutant content is not used, the emission factor is given in unit of pounds per SCC unit and the default emission factor multiplier is given as 1 with no units.

The control efficiency multiplier is a percentage multiplier which is applied to the NEDS pollutant control efficiency. The NEDS pollutant categories are coded as follows: 1 = particulate; 2 = sulfur dioxide; 3 = nitrogen oxides; 4 = hydrocarbons; and 5 = carbon monoxide. Thus, if the HATREMS pollutant is a particulate, the control device multiplier would be 100% of the control efficiency provided by NEDS for particulates (NEDS pollutant Code 1).

Finally, the action code designates whether the data keypunched are to be added (A), has been changed (C), or is to be deleted (D) from HATREMS.

B. Data Coding Methodology and Results

The following paragraphs describe the methodology used in coding the point source data for HATREMS:

1. Review of reference reports: A review of the reference material was performed and a listing of specific pollutants to be considered in this study was derived. Table 4 presents a summary of the availability of data in the principal references by specific pollutant.

2. Preparation of data coding forms: Data coding forms were prepared following specific formats for coding the point source emission factor data and emission factor origin as supplied by the project officer. For ease of coding, the data forms were designed for coding by specific pollutant. Figures 2 and 3 present example data forms for "Point Source Emission Factors--Card 3," and "SCC Emission Factor Origin."

Additional point source emission factor data, specifically Cards 1 and 2, were supplied by EPA. This latter set of cards contains the name and source units for each SCC.

3. Determination of HATREMS codes: The physical state (gas, particulate, or both) of each pollutant was determined (see Table 5). As indicated in Figures 2 and 3, the following data were assumed to be constant for each pollutant:

1. Pollutant code;

2. Control efficiency multiplier (percent); and

3. NEDS pollutant flag.

These data are also summarized in Table 5.

The pollutant code is a five-digit code: the first digit designates the pollutant state, and the remaining four digits are pollutant specific. The last four digits were obtained from the AEROS Manual of Codes.[9/]

The control efficiency multiplier is used to modify the control device information listed in NEDS; i.e., HATREMS utilizes the NEDS pollutant control device efficiency and the control multiplier stored in HATREMS to estimate emissions for each pollutant.

TABLE 4

SUMMARY OF POINT SOURCE DATA AVAILABILITY

Pollutant	W. E. Davis/ GCA Reports (Ref. 1-21)a/	EPA-450/ 2-73-001 (Ref. 22)a/	HATREMS Partial Final Report (Ref. 36)a/	HATREMS Emission Factor Forms (Ref. 49)a/	AP-42 (Ref. 60)a/
Ammonia			Xb/	X	X
Arsenic	X	X	X	X	
Asbestos	X	X	X	X	
Barium	X				
Beryllium	X	X	X	X	
Boron	X				
Cadmium	X	X	X	X	
Chlorinated Compounds					
Chlorine			Xb/	X	X
Hydrogen chloride			Xb/	X	X
Chromium	X				
Copper	X				
Fluorinated Compounds					
Fluoride			X	X	X
Hydrogen fluoride			Xb/	X	X
Hydrogen sulfide			Xb/	X	X
Lead	X		Xc/		
Magnesium	X				
Manganese	X	X	Xb/	X	
Mercury	X	X	X	X	
Molybdenum	X				
Nickel	X	X	Xb/	X	
Phosphorus	X				
Polycyclic organic material			Xc/		
Selenium	X				
Silver	X				
Titanium	X				
Vanadium	X	X	Xb/	X	
Zinc	X				

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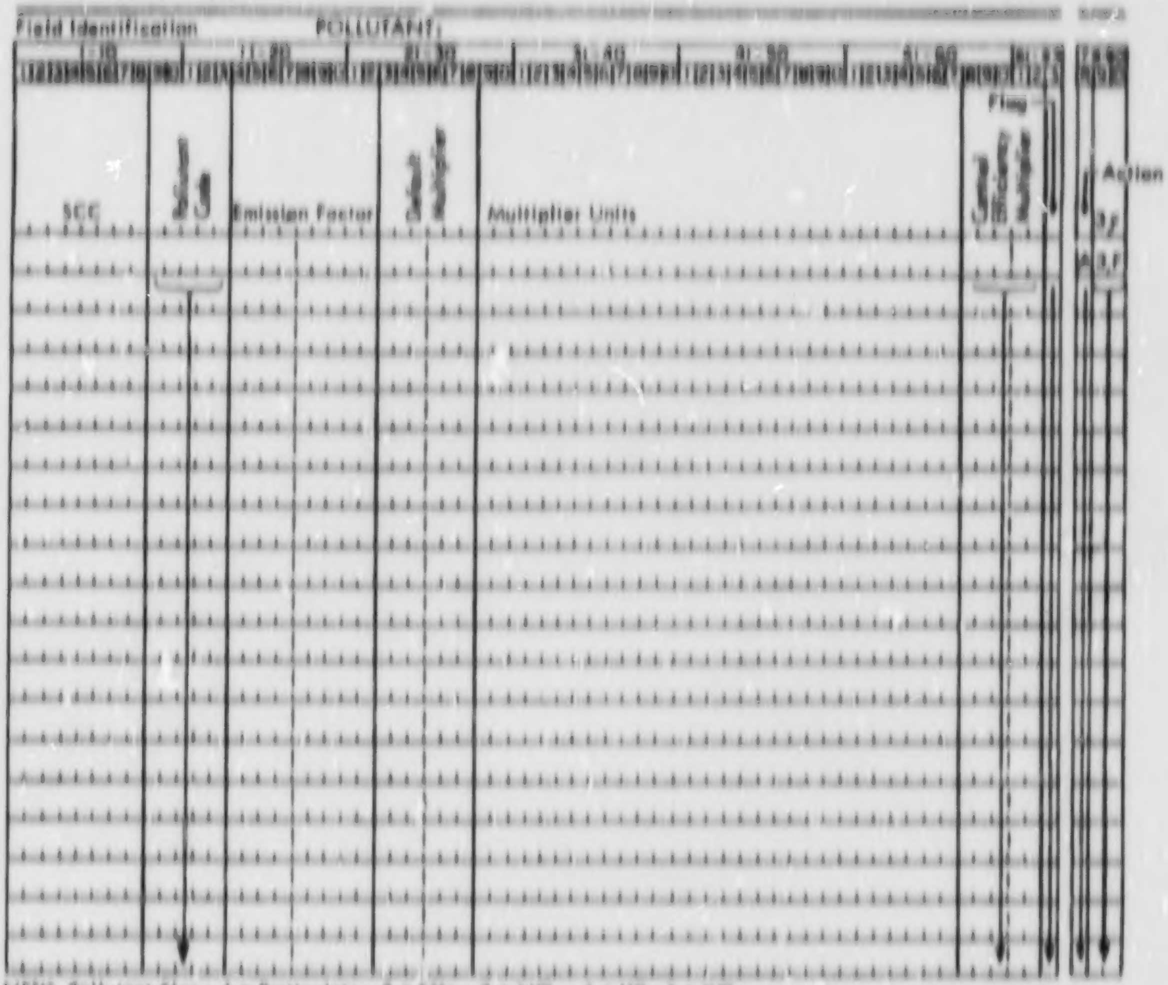
a/ As listed in the Bibliography.

b/ Emission factors only.

c/ Emissions data only.



Field Identification
POLLUTANT:
1-10
11-20
21-30
31-40
41-50
51-60
61-
Flag
Action
SCC
Emission Factor
Multiplier Units

NEDS Pollutant Flag : 1 = Particulate ; 2 = SO_2 ; 3 = NO_x ; 4 = HC ; 5 = CO
Action Code : A = Add ; C = Change ; D = Delete

Figure 2 - Point Source Emission Factors--Card 3 Format

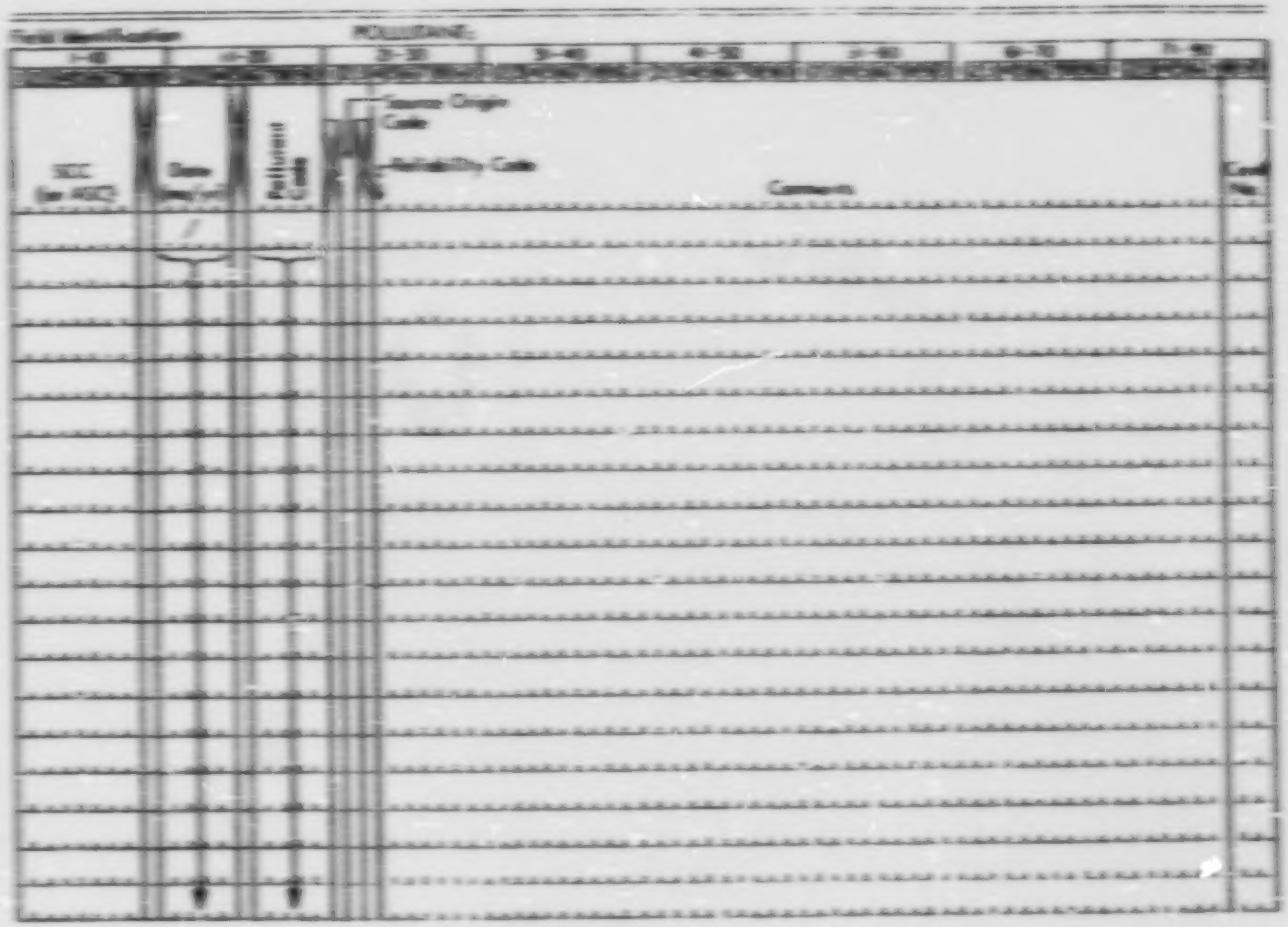

Field Identification
POLLUTANT:
1-10
11-20
21-30
31-40
41-50
51-60
61-70
71-80
SCC (or ASC)
Date (mo/yr)
Pollutant Code
Source Origin Code
Reliability Code
Comments
Card No.

Figure 3 - SCC Emission Factor Origin Card Format

TABLE 5

CODES FOR HAZARDOUS POLLUTANTS

Pollutant	Pollutant State	Pollutant Code	Control Efficiency Multiplier (%)[a]	NEDS Pollutant Flag[b]
Ammonia	Gas	D2506	0.0	1
Arsenic	Particulate	A2103	100.0	1
Asbestos	Particulate	A2801	100.0	1
Barium	Particulate	A2107	100.0	1
Beryllium	Particulate	A2105	100.0	1
Boron	Particulate	A2108	100.0	1
Cadmium	Particulate	A2110	100.0	1
Chlorinated Compounds				
Chlorine	Gas	D2215	0.0	1
Hydrogen chloride	Gas	D2502	0.0	1
Chromium	Particulate	A2117	100.0	1
Copper	Particulate	A2116	100.0	1
Fluorinated Compounds				
Fluoride	Particulate	A2202	100.0	1
Fluoride	Particulate and gas	E2202	0.0	1
Hydrogen fluoride	Gas	D2503	0.0	1
Hydrogen sulfide	Gas	D2402	0.0	1
Lead	Particulate	A2128	100.0	1
Magnesium	Particulate	A2160	100.0	1
Manganese	Particulate	A2132	100.0	1
Mercury	Particulate and gas	E2162	0.0	1
Molybdenum	Particulate	A2134	100.0	1
Nickel	Particulate	A2138	100.0	1
Phosphorus	Particulate	A2152	100.0	1
Polycyclic Organic Material				
Benzo(a)pyrene	Particulate and gas	E7262	100.0	4
Selenium	Particulate	A2156	100.0	1
Silver	Particulate	A2168	100.0	1
Titanium	Particulate	A2161	100.0	1
Vanadium	Particulate	A2164	100.0	1
Zinc	Particulate	A2167	100.0	1

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a/ Can be process specific if this data is available.

b/ NEDS pollutant flag: 1 = particulate; 2 = SO_2; 3 = NO_x; 4 = HC; and 5 = CO.

In general, HATREMS particulate pollutants were assumed to have identical control as total particulate (control efficiency multiplier = 100%; NEDS pollutant flag code = 1). In addition, gaseous pollutants were assumed not to be controlled by particulate control equipment (control efficiency multiplier = 0%; NEDS pollutant flag code = 1). Additional study is needed to determine the actual control efficiency multiplier based on the particle size of the pollutant versus the particle size of the total effluent. Future study may indicate that a pollutant is controlled equivalently to one of the other NEDS pollutants. It may also be possible to develop individual multipliers for specific processes. These data can be easily updated.

Finally, the source origin data were coded as:

A = EPA-450/2-73-001 (Reference 22 of Bibliography).

B = W. E. Davis/GCA reports (References 1 through 20 of Bibliography).

C = AP-42, April 1976 (Reference 60 of Bibliography)[7]

D = Other reference (References 21, 23 through 59, and 61 through 80 of Bibliography).

A reliability rating of each emission factor was added into Column 24 of the "SCC Emission Factor Origin Card." The ratings are based on AP-42[7] and are listed in Table 6.

In addition, the reference numbers, as specifically assigned in the bibliography, were coded in the comment column. Specific assumptions were also noted.

4. Coding of emission factors/default multipliers: A listing of sources and national emissions was prepared for most of the pollutants from the principal references (listed in Table 4). Source categories were considered for coding only if they represented more than 2.5% of the total national emissions. SCCs were designated, if possible, for each emission source category.

Point source emission factor data (Card 3) and SCC emission factor origin were coded for: (a) noncombustion sources; and (b) combustion sources. These data were then consolidated by pollutant.

TABLE 6

EMISSION FACTOR RELIABILITY RATINGS

Code	Reliability	Basis
A	Excellent	Field measurements of a large number of sources
B	Above average	Limited number of field measurements
C	Average	Limited data and/or published emission factors where the accuracy is not stated
D	Below average	Engineering estimates made by knowledgeable personnel
E	Poor	Estimated value; assumptions not given

The coded data were assessed in terms of the size of the source emissions coded in relation to the national emissions. SCCs were reviewed and new SCCs were recommended.

Final tabulations of coded data were sent to the project officer for keypunching and input into HATREMS (see Appendix A). These data were tabulated alphabetically by pollutant.

5. Calculation of Emission Factors for Combustion Sources: The following equation was used for determination of emission factors for combustion sources:*

$$\text{Emission Factor} = \frac{\text{lb pollutant emitted}}{\text{ton coal burned} \cdot \text{ppm}} =$$

$$\begin{matrix}\text{fraction of pollutant} \\ \text{entering flue gas}\end{matrix} \times \frac{\text{lb}}{10^6\ \text{lb} \cdot \text{ppm}} \times \frac{2{,}000\ \text{lb coal burned}}{\text{ton coal burned}}$$

where: Fraction of pollutant entering flue gas (from Reference 36 of Bibliography)
= 0.85 for Be, Mn, Ni (except for cyclone boilers)

= 1.0 for Cl, F, Hg

= 0.90 for As

= 0.75 for Ni (for cyclone boilers)

Example: For lead (A2128), bituminous coal electrical generation (SCC = 10100201)

$$\text{Emission Factor} = 0.90 \times \frac{1}{10^6} \times 2{,}000 = 0.0018\ \frac{\text{lb lead emitted}}{\text{ton coal burned} \cdot \text{ppm}}$$

For all pollutants not listed above, the volatility of each pollutant was compared to the volatility of the pollutants listed above to derive equivalent factors.

The total national emissions calculated for each pollutant, based on the assumptions concerning volatility of metals, compare reasonably well with data supplied in References 1 through 20 (see Bibliography). This comparison is summarized in Table 7. The percentage difference between the

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* Example for SCC = 10100201.

TABLE 7

COMPARISON OF DATA FOR COMBUSTION SOURCES

Pollutant	Year[a/]	Data Source	Emission Factor (lb/ton-ppm)	Default Multiplier (ppm)	National Emissions (tons/yr)
Arsenic	1968	MRI Coded	0.0018	28	12,827
		Bib. Ref. 1	0.0022	5.44	3,095
		Combination[b/]	0.0018	5.44	2,492
Barium	1969	MRI Coded	0.0017	36	15,792
		Bib. Ref. 3	0.0007	89	16,066
		Combination[b/]	0.0017	89	39,041
Beryllium	1968	MRI Coded	0.0017	20	8,653
		Bib. Ref. 4	0.0020	1.9	980
		Combination[b/]	0.0017	1.9	822
Boron	1969	MRI Coded	0.0017	53	23,250
		Bib. Ref. 5	0.0013	59	19,583
		Combination[b/]	0.0017	59	25,822
Cadmium	1970	MRI Coded	0.0018	0.4	186
Chlorine	1969	MRI Coded	0.0020	1,500	774,126
Chromium	1969	MRI Coded	0.0017	14	6,141
		Bib. Ref. 7	0.0016	20.8	8,700
		Combination[b/]	0.0017	20.8	9,123
Copper	1969	MRI Coded	0.0017	13	5,703
		Bib. Ref. 8	0.0013	13	4,292
		Combination[b/]	0.0017	13	5,703
Fluoride	1969	MRI Coded	0.0017	81	41,803
		Bib. Ref. 36	-	-	32,500
Lead	1970	MRI Coded	0.0018	9	419
		Bib. Ref. 9	> 0.002	8.2	-
		Combination[b/]	0.0018	8.2	382
Magnesium	1970	MRI Coded	0.0017	800	351,667
		Bib. Ref. 10	0.0016	560	236,000
		Combination[b/]	0.0017	560	246,167

TABLE 7 (concluded)

Pollutant	Year[a]	Data Source	Emissions Factor (lb/ton-ppm)	Default Multiplier (ppm)	National Emissions (tons/yr)
Manganese	1968	MRI Coded	0.0017	46	19,902
		Bib. Ref. 11	0.0010	26.4	6,515
		Combination[b]	0.0017	26.4	11,422
Mercury	1968	MRI Coded	0.0020	0.2	102
		Bib. Ref. 12	0.0020	0.5	255
		Combination[b]	0.0020	0.5	102
Molybdenum	1970	MRI Coded	0.0017	4	1,758
		Bib. Ref. 13	0.0016	8	3,380
		Combination[b]	0.0017	8	3,516
Nickel	1968	MRI Coded	0.0017	16	3,570
		Bib. Ref. 14	-	-	400
Phosphorus	1970	MRI Coded	0.0020	62.77	32,571
		Bib. Ref. 15	-	59.2	-
		Combination[b]	0.0020	59.2	30,719
Selenium	1969	MRI Coded	0.0020	3	1,548
		Bib. Ref. 16	0.0013	8	2,625
		Combination[b]	0.0020	8	4,128
Silver	1970	MRI Coded	0.0018	0.08	36
		Bib. Ref. 17	0.0016	0.56	236
		Combination[b]	0.0018	0.56	260
Titanium	1970	MRI Coded	0.0017	589	258,500
		Bib. Ref. 18	0.0016	592	243,000
		Combination[b]	0.0017	592	260,156
Vanadium	1968	MRI Coded	0.0017	28	12,116
		Bib. Ref. 19	0.0013	22.5	7,292
		Combination[b]	0.0017	22.5	9,736
Zinc	1969	MRI Coded	0.0018	22	10,218
		Bib. Ref. 20	0.0013	54.6	17,958
		Combination[b]	0.0018	54.6	25,359

---

[a] Coal consumption by year: 1968 = 508,990,000 tons; 1969 = 516,084,000 tons; and 1970 = 517,156,000 tons.

[b] MRI coded emission factor with reference default multiplier.

[c] Calculated value based on emission factor x default multiplier x annual consumption.

coded emission factors and those reported in referenced reports ranges from 0 to 43%.

In addition, comparison of the coded emission factors with Reference 22 (see Bibliography) indicates some discrepancies. Assumptions for control equipment efficiency were not specified, making comparison unreliable. Major differences in the emission factors were found for beryllium, manganese, and nickel as controlled by scrubbers.

6. *Comparison of MRI coded data with Reference 49 (see Bibliography)*: Data previously coded (Reference 49) were analyzed. References for default multipliers of noncombustion sources had not been documented and in most cases, these data were not found in References 1 through 87 (see Bibliography).

The combustion source data given in Reference 49 appear to be similar to the calculated data obtained in this study. The default multipliers represent the pollutant concentrations in the various types of coal and fuel oil. Pollutant concentrations in coal and oil, as used in this study and found in Reference 41, are listed in Table 8 by pollutant. These concentrations agree well with the data found in Reference 49. In addition, the combustion source emission factors found in Reference 49 agree well with those factors calculated by MRI.

7. *Determination of additional SCCs needed*: SCCs should be added for sources which represent a large percentage of the total emission of a pollutant. Recommendations for additional SCCs are summarized in Table 9.

TABLE 9

POLLUTANT CONCENTRATION IN COAL AND OIL (BIBLIOGRAPHY REFERENCE 41)

Pollutant	Concentration in Coal (ppm) Anthracite Coal	Bituminous Coal	Lignite	Residual Oil	Distillate Oil
Ammonia	-	-	-	-	
Arsenic	10.0	28.0	-	0.30	0.06
Asbestos	-	-	-	-	
Barium	58.0	36.0	303.0	0.67	
Beryllium	3.0	2.0	0.2	0.09	
Boron	1.0	53.0	41.0	0.11	
Cadmium	0.10	0.4	-	2.02	
Chlorinated Compounds:					
Chlorine	1,500	1,500	2,000	16.23	
Hydrogen chloride	-	-	-	-	
Chromium	120.0	14.3	4.1	1.78	
Copper	75.0	13.0	8.0	10.0	0.05
Fluorinated Compounds:					
Fluoride	110.9	81.0	-	-	
Hydrogen fluoride	-	-	-	-	
Hydrogen sulfide	-	-	-	-	
Lead	9.0	9.0	6.0	0.04	
Magnesium	-	-	-	-	
Manganese	182.0	46.0	31.0	2.08	0.13
Mercury	0.3	0.2	-	0.02	
Molybdenum	10.0	4.0	2.0	2.30	
Nickel	50.0	14.0	3.0	50.27	
Phosphorus	-	-	-	-	
Polycyclic organic material	-	-	-	-	
Selenium	0.20	3.0	-	0.36	
Silver	-	-	-	-	
Titanium	600.0	589.0	-	5.41	
Vanadium	13.0	28.0	9.0	57.36	
Zinc	33.0	22.0	12.0	-	

TABLE 9

SUMMARY OF RECOMMENDATIONS FOR ADDITIONAL SCCs

Pollutant	Source	SCC Category	% of National Emissions	SCC Units
Boron	Frit Manufacturing - General	3-05-013	4.3	Tons Produced
	Boron Processing - General	3-05-040	21.8	Tons Produced
	Glass Manufacturing - General	3-05-014	9.1	Tons Produced
Chlorine	Chlorine Manufacturing - Liquefaction	3-01-007	> 2.5	Tons Produced
	Chlorination of Organic Compounds			
	- Thermal Chlorination Propane to CCl_4	3-01	> 2.5	Tons Produced
	- Thermal Chlorination Propane to Perchloroethylene	3-01	> 2.5	Tons Produced
	Petroleum Miscellaneous - Chlorination of Propane	3-06-008	55	10^3 Cubic Feet
	Sulfate Pulping - Bleaching	3-07-001	> 2.5	Tons Produced
	Sulfite Pulping - Bleaching	3-07-002	> 2.5	Tons Produced
	Glass Manufacturing - General	3-05-014	5.3	Tons Produced
Chromium	Ferroalloy Open Furnace - General	3-03-006	68.3	Tons Produced
Hydrogen Chloride	Adipic Acid - Adiponitrile Manufacturing	3-01-001	33.1	Tons Produced
	Chlorination of Organic Compounds			
	- Chlorination of Carbon Disulfide	3-01	> 2.5	10^3 Tons Produced
	- Chlorination of Ethylene	3-01	> 2.5	10^3 Tons Produced
	- Chlorohydrination of Allyl Chloride	3-01	> 2.5	10^3 Tons Produced
	- Chlorohydrination of Propylene	3-01	> 2.5	10^3 Tons Produced
	- Hydrochlorination of Ethylene	3-01	> 2.5	10^3 Tons Produced
Fluorides	Hydrogen Fluoride Alkylation - General	3-01	3.7	Tons Produced
Hydrogen Sulfide	Petroleum Miscellaneous - Sulfur Plant	3-06-008	20.6	1,000 Barrels Refined
	Natural Gas Processing - General	3-06	3.1	10^6 Cubic Feet

TABLE 9 (Continued)

Pollutant	Source	SCC Category	% of National Emissions	SCC Units
Lead	Lead Alkyl Manufacturing		<1	
	- Electrolytic Process	3-01		Tons Processed
	- Sodium Lead Alloy Process	3-01		Tons Processed
	- Recovery Furnace			
	- TEL Process Vents			
	- TML Process Vents			
	- Sludge Pits			
	Lead Oxide Production	3-04-004	<1	
	- Lead Oxide Barton Pot			Tons Produced
	- Lead Oxide Calcining Furnace			
	- Lead Oxide Hammermill			
	- Lead Oxide Surge Hopper			
	- Refining Kettles			Tons Metal Charged
	Lead Battery	3-04-005	<1	Tons Batteries
	- Lead Oxide Mill			
	- Lead Reclaim Furnace			
	- Small Parts Casting			
	Miscellaneous Casting and Fabrication	3-04-050	<1	Tons Produced
	- Cable Covering Melting Kettle			
	- Ammunition			
	- Bearing Metal			
	- Type Metal			
	- Metallic Lead			
	- Lead Solder Melt Pot			
	Glass Manufacture - Lead Glass	3-05-014	<1	Tons Produced
Magnesium	Magnesium Carbonate - Oxide Production	3-05-024	4.8	Tons Produced
Manganese	Ferroalloy Open Furnace - General	3-03-006	47.1	Tons Produced
Molybdenum	Ferroalloy Open Furnace - General	3-03-006	6.3	Tons Produced

TABLE 9 (Concluded)

Pollutant	Source	SCC Category	% of National Emissions	SCC Units
Phosphorus	Fertilizer - Triple Superphosphate	3-01-029	19.8	Tons Produced
	- Grinding			
	- Drying			
	- Cooling			
	Elemental Phosphorus Production	3-01	6.2	Tons Produced
	- Briquetting/Sintering			
	- Flares			
	- Furnace Operations			
	- Grinding			
	- Ore Handling			
Selenium	Glass Manufacturing General	3-05-014	21	Tons Produced
Zinc	Zinc Smelting - Zinc Oxide Production	3-03-030	5.1	Tons Produced

V. AREA SOURCE EMISSION FACTOR DATA

Task IV consisted of the development and coding of emission factor data for area source data based on the NEDS Area Source Categories (ASCs). The following sections: (a) list the area source data required in the HATREMS data base; (b) describe the data coding methodology; and (c) show special computational techniques used in deriving the emission factors.

A. Data Requirements

The following data were designated for characterizing the area source emissions by pollutant and NEDS Area Source Category (ASC):

1. Emission factor, in units of pounds per ASC source rate unit times the pollutant content of the raw material.

2. Default multiplier, equal to 1 or the pollutant content of the raw material.

3. Multiplier units, specified for (2).

4. Action code, designating whether the data keypunched is to be added (A), has been changed (C), or is to be deleted (D) from HATREMS.

5. Date entered into HATREMS.

6. Source origin code: A = Reference 22, B = References 1 through 20, C = Reference 60, D = other reference (see Bibliography).

7. Reliability code, as defined in Bibliography Reference 60: A = excellent, B = above average, C = average, D = below average, and E = poor.

B. Data Coding Methodology

The following steps describe the methodology for coding the area source data for HATREMS:

1. Review of reference reports: A review of the reference material was performed. The following general area source categories were developed:

a. Category I - Combustion sources: coal, oil, natural gas, wood, and coke.

b. Category II - Solid waste disposal: incineration and open burning.

c. Category III - Highway vehicles: light duty gasoline, heavy duty gasoline and heavy duty diesel.

d. Category IV - Other vehicles: off-highway vehicles (e.g., farm and construction equipment), aircraft, locomotives, inboard and outboard powered vessels.

e. Category V - Miscellaneous sources: forest wildfires, fugitive dust sources, etc.

Table 10 presents a summary of the availability of area source emission factor data by pollutant and general category. As indicated, area source emission factors were not specified (i.e., in Bibliography References 1 through 87) for the following pollutants: ammonia, asbestos, hydrogen chloride, hydrogen fluoride, and hydrogen sulfide. In addition, only limited data were found for Categories III and IV (highway and other vehicles).

2. Preparation of data coding forms: Data coding forms were prepared following specific formats for coding the area source emission factor data and emission factor origin data as supplied by the project officer. Figures 4 and 5 present coded data forms for "Area Source Emissions Factors" - Cards 1, 2, and Figure 6 presents the example format for Card 3. Emission Factor Origin cards (see Figure 2) were used in the same manner as the point sources.

3. Coding of area source emission factors--Cards 1 and 2: Cards 1 and 2 (as shown in Figures 4 and 5, respectively) contain data on the source category name, source rate units and source activity factor units for each ANC. These data were coded on the basis of information supplied by the project officer and a listing of area source codes in the AEROS Manual of Codes.2/

4. Coding of area source emission factors--Card 3 and emission factor origin: Area source emission factor data (Figure 6) and emission factor origin (Figure 2) were coded for each of the general specified categories.

An assessment of the coded data indicated that data were available only for ANCs 01-04, 07-10, 13-14, 16-17, 23, 55-59. However, major emissions from area sources (i.e., emissions representing more than 2.5% of the total national emissions of that pollutant) were coded. In addition, all available data were coded for lead.

TABLE 10

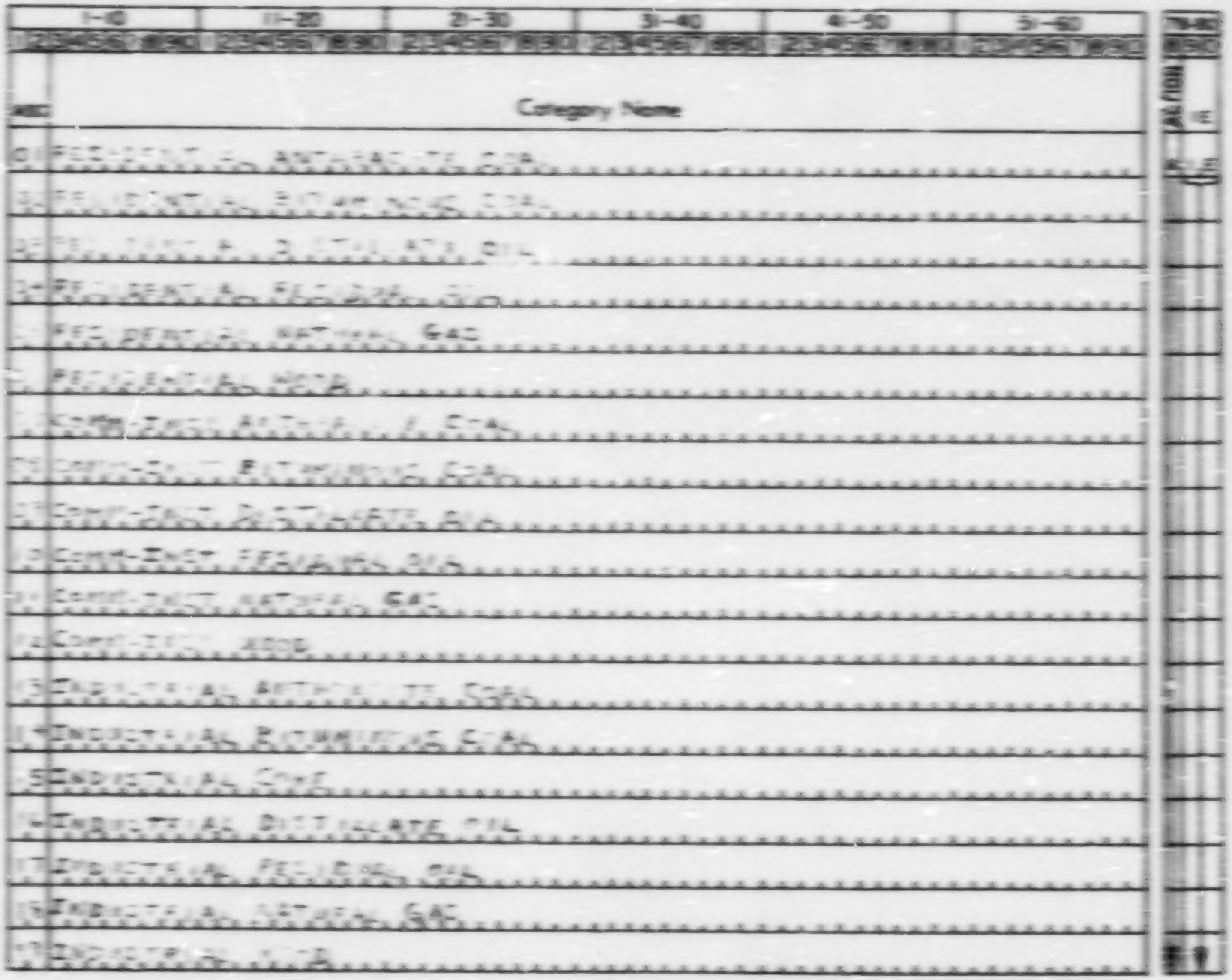
SUMMARY OF AREA SOURCE DATA AVAILABILITY

Pollutant	ASC Category				
	I	II	III	IV	V
Ammonia[a]					
Arsenic	X	X			X
Asbestos[a]					
Barium	X	X			X
Beryllium	X	X			
Boron	X	X			
Cadmium	X	X			X
Chlorinated compounds:					
Chlorine	X	X			
Hydrogen chloride[a]					
Chromium	X	X			X
Copper	X	X			X
Fluorinated compounds:					
Fluoride	X	X			X
Hydrogen fluoride[a]					
Hydrogen sulfide[a]					
Lead	X	X	X	X	X
Magnesium	X				X
Manganese	X	X			X
Mercury	X				
Molybdenum	X	X			
Nickel	X	X			X
Phosphorus	X				
Polycyclic organic material	X				X
Selenium	X	X			
Silver	X	X			
Titanium	X				X
Vanadium	X	X			X
Zinc	X	X			X

---

[a] Area source data not available.

AREA SOURCE EMISSION FACTORS — CARD 1 (Occurs Once per ASC)



ASC	Category Name
01	RESIDENTIAL ANTHRACITE COAL
02	RESIDENTIAL BITUMINOUS COAL
03	RESIDENTIAL DISTILLATE OIL
04	RESIDENTIAL RESIDUAL OIL
05	RESIDENTIAL NATURAL GAS
06	RESIDENTIAL WOOD
07	COMM-INST ANTHRACITE COAL
08	COMM-INST BITUMINOUS COAL
09	COMM-INST DISTILLATE OIL
10	COMM-INST RESIDUAL OIL
11	COMM-INST NATURAL GAS
12	COMM-INST WOOD
13	INDUSTRIAL ANTHRACITE COAL
14	INDUSTRIAL BITUMINOUS COAL
15	INDUSTRIAL COKE
16	INDUSTRIAL DISTILLATE OIL
17	INDUSTRIAL RESIDUAL OIL
18	INDUSTRIAL NATURAL GAS
19	INDUSTRIAL WOOD

Figure 4 - Area Source Emission Factors—Card 1 Coded Data

AREA SOURCE EMISSION FACTORS — CARD 1 (Occurs Once per ASC)

1–10	11–20	21–30	31–40	41–50	51–60	79–80
1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	890

ASC	Category Name	ACTION
[illegible]	[illegible]	
[illegible]	[illegible]	
38	INDUSTRIAL ON-SITE INCINERATION	
39	COMMERCIAL ON-SITE INCINERATION	
40	RESIDENTIAL OPEN BURNING	
41	INDUSTRIAL OPEN BURNING	
[illegible]	[illegible] OPEN BURNING	
43	OFF HIGHWAY GASOLINE VEHICLES	
44	OFF HIGHWAY DIESEL VEHICLES	
45	RAILROADS	
46	MILITARY AIRCRAFT LTO'S	
47	CIVIL AIRCRAFT LTO'S	
48	COMMERCIAL AIRCRAFT LTO'S	
49	COAL VESSELS	
50	DIESEL OIL VESSELS	
51	RESIDUAL OIL VESSELS	
52	GASOLINE [illegible]	
53	SOLVENT PURCHASED	
54	GASOLINE MARKETED	

Figure 4 – (Continued)

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AREA SOURCE EMISSION FACTORS — CARD 1 (Occurs Once per ASC)

1–10	11–20	21–30	31–40	41–50	51–60	
1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	[illegible]
ASC	Category Name					ACTION IE
55	UNPAVED ROAD TRAVEL					
56	UNPAVED AIR STRIP LTO'S					
57	CONSTRUCTION					
58	MISCELLANEOUS WIND EROSION					
59	LAND TILLING					
60	FOREST WILD FIRES					
61	MANAGED BURNING (SLASH/PRESCRIBED BURNING)					
62	AGRICULTURAL FIELD BURNING					
63	FROST CONTROL (ORCHARD HEATERS)					
64	STRUCTURAL FIRES					
AA	LIGHT DUTY GASOLINE FUEL					
AB	HEAVY DUTY GASOLINE FUEL					
AC	HEAVY DUTY DIESEL FUEL					

Figure 4 - (Concluded)

AREA SOURCE EMISSION FACTORS — CARD 2

1–10	11–20	21–30	31–40	41–50	51–60	61–70	71–80
1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890

NOS	Source Rate Units	Source Activity Factor Units	ACTION	[illegible]
01	TONS			
02	TONS			
03	THOUSAND GALLONS			
04	THOUSAND GALLONS			
05	MILLION CUBIC FEET			
06	TONS			
07	TONS			
08	TONS			
09	THOUSAND GALLONS			
10	THOUSAND GALLONS			
11	MILLION CUBIC FEET			
12	TONS			
13	TONS			
14	TONS			
15	TONS			
16	THOUSAND GALLONS			
17	THOUSAND GALLONS			
18	MILLION CUBIC FEET			
19	TONS		2	9

Figure 5 - Area Source Emission Factors—Card 2 Coded Data

AREA SOURCE EMISSION FACTORS — CARD 2

1-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80
1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890

[illegible]	Source Rate Units	Source Activity Factor Units	ACTION	[illegible]
36	MILLION CUBIC FEET			
37	TONS			
38	TONS			
39	TONS			
40	TONS			
41	TONS			
42	TONS			
43	THOUSAND GALLONS			
44	THOUSAND GALLONS			
45	THOUSAND GALLONS			
46	LANDING/TAKE OFF CYCLES			
47	LANDING/TAKE OFF CYCLES			
48	LANDING/TAKE OFF CYCLES			
49	TONS			
50	THOUSAND GALLONS			
51	THOUSAND GALLONS			
52	THOUSAND GALLONS			
53	TONS			
54	THOUSAND GALLONS			

Figure 5 – (Continued)

AREA SOURCE EMISSION FACTORS — CARD 2

1-10 | 11-20 | 21-30 | 31-40 | 41-50 | 51-60 | 61-70 | 71-80

REC.	Source Rate Units	Source Activity Factor Units	ACTION
55	THOUSAND VEHICLE MILES		
56	LANDINGS/TAKE OFF CYCLES		
57	ACRES		
58	ACRES		
59	ACRES		
60	ACRES	TONS PER ACRE	
61	ACRES	TONS PER ACRE	
62	ACRES	TONS PER ACRE	
63	NUMBER OF ORCHARD HEATERS	NUMBER OF DAYS FIRED PER YEAR	
64	NUMBER OF STRUCTURAL FIRES PER YEAR		
8A	THOUSAND GALLONS		
8B	THOUSAND GALLONS		
8C	THOUSAND GALLONS		

Figure 5 - (Concluded)

1-10		11-20		21-30 31-40 41-50 51-60	79-80
1234567890		1234567890		1234567890 1234567890 1234567890 1234567890	90
ASC	Pollutant Code	Emission Factor	Default Multiplier*	Multiplier Units (Name)	ACTION

*Blank if NEDS Area Source

Figure 6 - Area Source Emission Factors—Card 3 Format

Copies of all coded data forms were supplied to the project officer for review and keypunched (see Section VII) for input into HATREMS. The keypunched data are listed in Appendix A.

C. Computational Techniques

The following paragraphs describe the methodology/computation techniques used in deriving emission factors for each ASC/pollutant.

1. Category I - Combustion Sources: This category contains residential, commercial/institutional, and industrial burning of coal, oil, natural gas, wood, and coke. ASCs 01 through 20 are represented. The methodology used to calculate emission factors for this category is essentially the same as the methodology described for point sources in Section IV.

$$\text{Emission Factor, } \frac{\text{lb pollutant emitted}}{\text{ton coal burned - ppm}} =$$

$$X\text{, fraction of pollutant entering flue gas} \times \frac{\text{lb}}{10^6 \text{ lb - ppm}} \times \frac{2{,}000 \text{ lb}}{\text{ton}}$$

where X is a derived value based on data specified in References 36 and 41 (see Bibliography)

Example: For arsenic (A2103), anthracite coal residential heating (ASC = 01):

$$\text{Emission Factor} = 0.005 \times \frac{1}{10^6} \times 2{,}000 = 0.00001 \frac{\text{lb arsenic emitted}}{\text{ton coal burned - ppm}}$$

Assumptions for each ASC are given in Table 11.

In addition, specific calculations were performed for polycyclic organic material, i.e., tons BaP emitted per ASC unit consumed. These data are also based on data specified in Bibliography 41.

2. Category II - Solid Waste Disposal: This category contains incineration and open burning. Only limited data were found for this category, (Bibliography References 81 and 84) and these data were coded as ASCs = 21, 22, and 23. ASCs 21 and 22 were assumed to have the same default multipliers as ASC 23, since specific data were not available. The assumption was made that 100% of the pollutant in refuse is emitted. Thus, the emission factor can be calculated as:

TABLE 11

ASSUMPTIONS FOR CALCULATION OF AREA SOURCE EMISSION FACTORS (CATEGORY I)

ASC	Comment[a]
01	X = 0.005; Except for Br, Cl, F, BaP (X = 1), Hg (X = 0.9) and Se (X = 0.7)
02	X = 0.01; Except as in 01
03	X = 0.005; Assumed 7.5 lb/gal distillate oil
04	X = 0.005; Same as 03
05	Data not available (natural gas)
06	Data not available (wood)
07	Same as point sources (SCC = 10100102)
08	Coded the same as point sources (SCC = 10100202 and 10200202)
09	Coded the same as point sources (SCC = 10100501)
10	Coded the same as point sources (SCC = 10100401)
11	Data not available (natural gas)
12	Data not available (wood)
13	Coded the same as point sources (SCC = 10200101)
14	X = 0.75 for all pollutants coded as Mn X = 0.90 for all pollutants coded as As X = 1.0 for Br, Cl, F
15	Data not available (coke)
16	Coded the same as point sources (SCC = 10100501 and 10200501)
17	Coded the same as point sources (SCC = 10100401 and 10200401)
18	Data not available (natural gas)
19	Data not available (wood)

---

[a] X = fraction of pollutant entering flue gas

$$\text{Emission Factor} = 1 \times \frac{1 \text{ ton}}{10^6 \text{ tons} \cdot \text{ppm}} \times \frac{2{,}000 \text{ lb}}{\text{ton}}$$

$$= 0.002 \frac{\text{lb pollutant}}{\text{ton refuse burned} \cdot \text{ppm}}$$

The default multipliers were coded as parts per million or percentage of pollutant in refuse burned.

3. Category III - Highway Vehicles and Category IV - Other Vehicles: Category III is represented by ASCs AA, AB, and AC; and Category IV by ASCs 39 and 44 through 52. Gasoline and diesel powered vehicles are included. Lead (in gasoline) was the only pollutant coded.

Default multipliers for gasoline were determined from Reference 85 and derived in units of grams per gallon of pollutant in gasoline. The following equation was used in deriving the emission factor (assumes 75% of the lead in gasoline is emitted in the exhaust):

$$\text{Emission Factor} = \frac{\text{lb Pb}}{1{,}000 \text{ gal.} \cdot \text{g Pb/gal gasoline}} =$$

$$0.75 \times \frac{\text{lb}}{10^6 \text{ lb} \cdot \text{ppm}} \times \frac{\text{ppm}}{0.00255 \text{ g/gal gasoline}} \times$$

$$\frac{5.61 \text{ lb}}{\text{gal. gasoline}} \times 1{,}000 = \frac{1.65 \text{ lb Pb}}{1{,}000 \text{ gal.} \cdot \text{g Pb/gal gasoline}}$$

$$1 \text{ ppm Pb} = 0.00255 \text{ g Pb/gal}$$

$$\underset{\text{(density of gasoline)}}{\frac{0.66 \text{ g Pb}}{\text{cm}^3}} \times \frac{1{,}000 \text{ cm}^3}{1 \text{ liter}} \times \frac{3.785 \text{ liters}}{1 \text{ gal.}} \div 10^6 =$$

$$0.0025 \frac{\text{g Pb}}{\text{gal. of gasoline}}$$

4. Category V - Miscellaneous Sources: Fugitive dust sources (ASCs 55 through 59) and area burning (ASCs 60 through 64) are included in this category. Limited pollutant data are available.

Table 12 presents a summary of pollutant concentrations in dust (i.e., earth's crust). These data were used as default multipliers for the fugitive dust categories (ASC = 55, 56, 59). Wind erosion emissions (ASC = 58) and construction (ASC = 57) are too variable across the country to determine nationwide averages.

Emissions data for area burning were found to be limited to polycyclic organic material (Bibliography Reference 86).

TABLE 12

DEFAULT MULTIPLIERS FOR FUGITIVE DUST AREA SOURCES

	Average ppm in Dust	Bibliography Reference for Concentration Data
Ammonia	Not applicable (N.A.)	
Arsenic	0.05a/	82
Asbestos	-	
Barium	3.0b/	82
Beryllium	-	
Boron	-	
Cadmium	0.01b/	82
Chlorinated compounds	-	
Chlorine	N.A.	
Hydrogen chloride	N.A.	
Chromium	1.8a/	82
Copper	0.8c/	84
Fluorinated compounds	-	
Fluoride	3.0a/	82
Hydrogen fluoride	N.A.	
Hydrogen sulfide	N.A.	
Lead	0.4a/	82
Magnesium	140b/	81
Manganese	18.3b/	82
Mercury	-	
Molybdenum	-	
Nickel	0.8b/	82
Phosphorus	-	
Polycyclic organic material	-	
Benzo(a)pyrene	-	
Selenium	-	
Silver	-	
Titanium	60b/	82
Vanadium	1.4b/	82
Zinc	0.5a/	82

---

a/ Assumed ratio of element composition in soil and element composition in dust was equal to one.

b/ Measured ratio of element composition in soil and element composition in dust was used. Ratio was used to modify soil element concentration figures (Bibliography References 81 and 82).

c/ No modifications of published data (Bibliography Reference 84).

VI. "FREE" AREA SOURCE EMISSION FACTOR DATA

Task V consisted of the development and coding of emission factor data for "free" area sources. "Free" area sources can be defined as area sources which are not currently defined as NEDS Area Source Categories. The following subsections present: (a) data requirements; and (b) methodology and results for Task V.

A. Data Requirements

The data required for characterizing the "free" area sources were as follows:

1. State;
2. County;
3. Air Quality Control Region (AQCR);
4. Area source category, not defined previously;
5. Pollutant code, as defined in Table 5;
6. Year of record;
7. Source rate, in source specific units;
8. Source activity factor, in source specific units as required;
9. Emissions in units of tons per year; and
10. Comments.

B. Data Coding Methodology and Results

The following paragraphs describe the methodology for coding "free" area source data for HATREMS.

1. Review of references and specification of "free" source categories: Table 13 presents a summary of the availability of "free" area source emission factor data by pollutant. This table represents a compilation of all emission factor data as given in the bibliography. The emission factor reliability, with the exception of leaf burning (POM), is poor.

TABLE 13

SUMMARY OF "FREE" AREA SOURCE DATA AVAILABILITY

Pollutant	"Free" Area Source Category	Source Extent Units	Emission Factor (lb/unit)	% of National Emission	Emission Factor Reliability Code	Bibliography Reference
Asbestos	Brake lining wear	1,000 VMT	0.0005	0.4	E	22
	Steel fireproofing	Tons asbestos applied	40	0.9	E	22
	Boiler insulating cement	Tons asbestos applied	227	3.0	E	22
	Construction	Tons asbestos applied	25	0.9	E	22
Barium	Rubber tire wear	1,000 VMT	0.0011	4.0	E	3
Cadmium	Rubber tire wear	1,000 VMT	0.00001	0.2	E	6
	Fungicides	1,000 gal. of spray	0.05	0.01	E	22
	Super-P-fertilizers	Tons of fertilizer	0.0002	0.02	E	22
	Motor oil consumption	1,000 VMT	0.000002	0.04	E	22
	Cigarettes	1,000 cigarettes	0.000002	0.03	E	22
Mercury	Agricultural spraying	Tons of Hg in the spray material	1,000	2.3	E	12
	Pharmaceuticals	Tons of Hg applied	400	0.31	E	22
	Dental preparations	Tons of Hg handled	20	0.16	E	22
	General lab handling	Tons of Hg used	80	6.0	E	22
Zinc	Rubber tire wear	1,000 VMT	0.016	5.3	E	30
POM (total)	Leaf burning	Tons of leaves burned	0.03	-	B	39

Analysis of the data indicates that boiler insulating cement (asbestos), general laboratory handling (mercury), and rubber tire wear (barium and zinc) are the only sources with emissions greater than 2.5% of the total national emissions of the particular pollutant.

Boiler insulating cement as well as steel fireproofing and construction emissions of asbestos were not coded because of the lack of data on tons of asbestos applied.

Laboratory handling, dental preparations and pharmaceuticals are general sources of mercury emissions. However, only limited data are available on the extent (tons of mercury used, handled, or applied) of the aforementioned sources; therefore, these sources were not coded.

Rubber tire wear, brake lining wear, and motor oil consumption all have source extent units of thousands of vehicle miles traveled. VMT data are available by state from the Department of Transportation[10] and were found to be suitable for coding of these categories as "free" area sources.

An alternate approach to defining these three "free" area sources could have been to utilize existing area source categories (i.e., AA = light duty gasoline vehicles; AB = heavy duty gasoline vehicles; and AC = heavy duty diesel fuel vehicles). The emission factors could be converted from units of thousands of vehicle miles traveled to thousands of gallons burned, by dividing by the fuel economy (miles per gallon). Reference 10 contains an overall conversion factor (which includes passenger vehicles, buses, and various truck types) of 12.13 miles/gal for 1974. It is apparent that the use of this conversion factor is highly dependent on the year studied, whereas vehicle miles traveled is less variable. Fuel economy is a function of vehicle speed, vehicle mix, and percentage of smaller (more efficient) automobiles. In addition, emissions from rubber tire wear, brake lining wear, and motor oil consumption are more directly related to vehicle miles traveled than gallons of fuel burned.

The remaining source categories in Table 13 (i.e., fungicides, superphosphate fertilizers, cigarettes, agricultural spraying, and leaf burning) have emissions less than 2.5% of the national emissions by pollutant. These data were not coded.

By comparison, Table 14 presents a summary of nonindustrial sources of particulate pollution. These data indicate that minor sources of emissions (i.e., rubber tires, cigarette smoke, aerosols from spray cans, and ocean salt spray) represent only slightly more than 1% of the total national particulate emissions from nonindustrial sources (123×10^6 tons/year). The total particulate emissions in the continental United States were estimated to be 141×10^6 tons/year, based on 1968 through 1970 data.

TABLE 14

NONINDUSTRIAL AREA SOURCES OF PARTICULATE POLLUTION IN THE UNITED STATES[11/]

Source	Emissions (10^6 tons/yr.)
Natural Dusts	63
Forest Fires	56.3[a/]
Wildfires	(37)
Controlled fires	
Slash burning	(6)
Accumulated litter	(11)
Agricultural burning	(2)
Transportation	1.2
Motor vehicles	
Gasoline	(0.42)
Diesel	(0.26)
Aircraft	(0.03)
Railroads	(0.22)
Water transport	(0.15)
Nonhighway use	
Agricultural	(0.079)
Commercial	(0.012)
Construction	(0.003)
Other	(0.026)
Incineration	0.931
Municipal incineration	(0.098)
On-site incineration	(0.185)
Wigwam burners	(0.035)
Open dump	(0.613)
Other Minor Sources	1.284
Rubber tires	(0.300)
Cigarette smoke	(0.230)
Aerosols from spray cans	(0.390)
Ocean salt spray	(0.340)
Other	(0.024)
Total	122.7

[a/] More recent estimates indicate that these should be as much as a factor of five lower.[12/]

2. *Preparation of data coding forms:* Data coding forms were prepared following specific formats for coding the area source emission factor data and emission factor origin data as supplied by the project officer. These data forms were presented in Section IV. In addition, a data coding form was prepared for "free" area source input (see Figure 7).

3. *Determination/coding of emission factors by "free" ASC:* "Free" area source emission factor data and emission factor origins were coded for each of the following categories:

- Rubber tire wear (barium, cadmium, and zinc)--AD,
- Brake lining wear (asbestos)--AE, and
- Motor oil consumption (cadmium)--AF.

The emission factors, data sources, and data reliabilities are given in Table 13. These emission sources all have source rates expressed in units of pounds per thousands of vehicle miles traveled. In coding the source rate data (see Figure 7), the source rate units were changed to millions of vehicle miles traveled and the emission factors were multiplied by 1,000.

4. *Determination/coding of activity levels by "free" ASC:* The activity level for the coded "free" area source categories is coded in terms of source rate units which may require multiplication by a source activity factor. For the three sources coded, the source activity factor was not required.

The source rate units for "free" area source categories AD, AE, and AF are all given per millions of vehicle miles traveled (10^6 VMT). Table 15 presents 1974 VMT and population data by state.[10] In order to determine the source rate by county, the following apportioning methodology was used:

$$\begin{array}{c}\text{Source Rate by}\\ \text{County } (10^6 \text{ VMT})\end{array} = \begin{array}{c}\text{Source Rate}\\ \text{for State } (10^6 \text{ VMT})\end{array} \times \frac{\text{County Population}}{\text{State Population}}$$

County data was determined from *County and City Data Book*, 1972.[13] An example of the "free" area source input coded data is shown in Appendix A.

It was originally felt that using the population over 18 years of age would be more meaningful. However, calculation of selected extreme areas indicated a difference in the apportioned value of less than 0.1%.

"FREE" AREA SOURCE INPUT

State	County	AQCR	ASC	Pollutant Code	[illegible]	Source Name	Source Activity Factor	Emissions (T/Yr)	Exp *	Comments	RETURN	[illegible]

* Power of 10 exponent for emissions (e.g. +1, -2)

Figure 7 - "Free" Area Source Input Format

TABLE 15

STATE POPULATION AND VEHICLE MILES TRAVELED DATA

State	1976 10^6 VMT[10]	1970 Population[13]	1970 % Population 18 yr[13]
Alabama	23,922	3,444,165	64.0
Alaska	2,095	300,382	60.1
Arizona	15,686	1,770,900	63.4
Arkansas	13,515	1,923,295	65.8
California	127,600	19,957,715	66.6
Colorado	16,156	2,207,259	64.8
Connecticut	18,005	3,031,709	66.2
Delaware	3,475	548,101	64.0
Florida	62,021	6,789,412	68.8
Georgia	35,082	4,589,575	64.0
Hawaii	3,920	768,561	64.1
Idaho	5,657	712,567	62.8
Illinois	59,210	11,109,935	65.7
Indiana	36,993	5,193,669	64.6
Iowa	19,065	2,824,376	65.3
Kansas	15,203	2,246,578	66.7
Kentucky	23,811	3,218,706	65.2
Louisiana	19,545	3,640,490	61.7
Maine	6,713	993,663	65.1
Maryland	23,896	3,922,399	64.7
Massachusetts	28,237	5,689,170	66.8
Michigan	55,749	8,875,083	63.2
Minnesota	24,588	3,804,971	63.5
Mississippi	13,736	2,216,912	61.7
Missouri	29,710	4,676,501	66.7
Montana	5,823	694,409	63.4
Nebraska	10,960	1,482,412	65.7
Nevada	4 195	488,738	65.1
New Hampshire	5,078	737,681	65.4
New Jersey	47,244	7,168,164	66.6
New Mexico	9,438	1,016,000	59.8
New York	65,262	18,236,951	67.8
North Carolina	35,000	5,082,059	65.2
North Dakota	4,371	617,761	63.2
Ohio	63,084	10,651,848	64.8
Oklahoma	21,494	2,559,229	67.2
Oregon	15,233	2,091,385	66.5
Pennsylvania	67,607	11,793,907	67.3

TABLE 15 (concluded)

State	1976 10^6 VMT[12]	1970 Population[13]	1970 % Population 16 yrs[11]
Rhode Island	5,566	948,845	68.2
South Carolina	20,012	2,590,516	62.9
South Dakota	5,093	665,507	63.5
Tennessee	30,756	3,923,[illegible]	66.0
Texas	78,691	11,195,431	64.1
Utah	7,457	1,059,273	59.8
Vermont	3,026	444,330	64.5
Virginia	33,636	4,648,494	65.7
Washington	22,585	3,409,169	65.9
West Virginia	10,118	1,744,237	66.5
Wisconsin	27,965	4,417,731	64.0
Wyoming	3,452	332,416	63.6
District of Columbia	7,957	756,510	70.3
Total	1,289,645		

5. *Analysis of "free" area source coded data*: All "free" area sources including those selected for coding were determined to be minor sources. Rubber tire wear emissions of barium, cadmium, and zinc represented 6%, 0.2%, and 5.3% of the respective national emissions of those pollutants. Brake lining wear represented 0.4% of the national emissions of asbestos, and motor oil consumption represented 0.04% of the national emissions of cadmium. All "free" area sources not coded should have little impact on an emissions inventory of any of the previously designated 26 pollutants.

VII. PROCESSING OF CODED HATREMS DATA

Data for the point, area, and "free" area sources, coded under Tasks III through V, respectively, were reviewed for discrepancies or coding errors and any errors were corrected. All completed coding forms were submitted to EPA for final review.

The major effort of this task was to keypunch and verify the coded data for only the area and "free" area sources (point source data were keypunched by EPA). These data were keypunched in MRI's Computation Center and machine verified for keypunching errors. The cards were listed on MRI in-house equipment and visually verified. Any errors were corrected.

The "free" area source data represented the major portion of the keypunched cards. Approximately 3,200 cards (i.e., one card per county) were keypunched for each pollutant/"free" area source category. Keypunching was simplified by duplicating a deck with blank fields for the "free" area source code and the pollutant code. Then, the data for these two fields were duplicated into each card for each of the following five cases:

"Free" Area Source Category	Pollutant
AD: Rubber tire wear	A2107: Barium
AD: Rubber tire wear	A2167: Zinc
AD: Rubber tire wear	A2110: Cadmium
AE: Brake lining wear	A2801: Asbestos
AF: Motor oil consumption	A2110: Cadmium

The keypunched area and "free" area source data cards were sent to EPA. These data cards, along with point source data cards, make up the HATREMS emission factor data base (i.e., the input to HATREMS).

VIII. HATREMS DATA BASE EVALUATION

HATREMS, when fully operational, will be capable of providing emission inventories on a national, state, county, air quality control region (AQCR), or specific source basis. The HATREMS output format will be modeled after the NEDS system. Utilizing the NEDS and HATREMS emissions inventories, the magnitude and location of virtually all the nation's criteria and selected hazardous pollutant sources will be readily available on a computerized system.

The credibility of HATREMS rests on the completeness and accuracy of the system's input data base for each pollutant. Three types of data are needed to calculate the emissions from a particular source operation:

- Process emission factor and default multiplier,
- Process material throughput rate, and
- Control device efficiency,

where the product of these three factors equals the emission rate. The key to an accurate emissions inventory for a particular source operation depends on the reliability and completeness of this input data.

A. Reliability

The NEDS system provides emission inventories for the five criteria pollutants. HATREMS will augment this by providing inventories for hazardous or trace noncriteria pollutants. Although major field testing and related studies have been undertaken in verifying the accuracy of the emissions data for the criteria pollutants, evaluation of hazardous pollutant emissions is limited.

HATREMS pollutant input data, especially the emission factors/default multipliers and control device removal efficiencies, are based on less than adequate data. Here adequate input implies data generated from a series of documented source tests. Much of the HATREMS coded input data are based on limited source testing, material balances, or engineering estimates. Only the process material throughput rate, which is already coded in the NEDS system, is believed to have a high degree of accuracy. Process material throughput rate is documented for most sources and available in plant production records.

HATREMS *emission factors*, as reported in the literature, usually span a wide range. This indicates that either (a) not all the processes within a Source Classification Code (SCC) category are similar and/or (b) the emission testing results are not reproducible. The procedure for coding emission factors, for each of the various SCC categories consisted of taking an average of the reported emission factors or using engineering judgment to determine the best factor available. Coding emission factors by SCC implies that a single emission factor/default multiplier combination is applicable to all the sources within a SCC category.

For some SCC categories, notably the combustion sources, a pollutant *default multiplier* is used in combination with a base emission factor (expressed in emission factor units per default multiplier unit) to obtain the total emission factor. The default multiplier usually specifies the pollutant concentration in the process feed material. Here again it is difficult to ascertain from the literature, what pollutant concentration (default multiplier) is typical for the feed material in a particular SCC category.

Even though the base emission factor may be reliable, the default multiplier may render the total emission factor unreliable for a particular source. For example, lead emissions from the combustion of coal in an electrical generation power boiler are coded as the product of a base emission factor, 0.0018 lb Pb emitted per ton coal burned per ppm Pb in coal times an appropriate default multiplier (in this case 9 ppm Pb in coal). Although the base emission factor is supported by adequate test data, the default multiplier is based on a typical lead content for bituminous coal. Because the actual lead content in coal may range from 4.3 to 47 ppm, the HATREMS total emission factor for the power boiler may deviate from the actual emission factor by a factor of 5.

The *control device efficiency* may introduce additional uncertainty in the calculated emission rate. HATREMS applies a control device multiplier to the NEDS SCC category control device efficiency. For example, it is assumed that an industrial coal-fired power boiler will have the same collection efficiency for noncriteria particulate pollutants as for total particulates. However, many of the combustion related hazardous materials are enriched in the fine particulate size ranges, which escape collection by conventional control equipment. This source of uncertainty will remain until removal efficiencies are adequately documented for HATREMS pollutants.

B. Completeness

Currently, there is considerable variation in reported national hazardous pollutant emissions inventories. Since NEDS/HATREMS have the capability of including all emitting source categories in the nation, the emission inventories produced by these sytems should be the most complete.

To be complete, the inventories generated by HATREMS need to include coded data for all pollutant/SCC categories. As indicated in Table 16 the percentage of each HATREMS pollutant emissions currently coded relative to estimated national emissions is far from being complete. Approximately 53% of the total HATREMS pollutant emissions are coded. In order to provide complete inventories, much of the remaining 47% of the uncoded emissions needs to be added to the data base. Only the emission factors for beryllium, chlorine, lead, and vanadium are entered in the system to such an extent as to provide complete inventories.

Some of the emission factors which apply to the remaining 47% of the uncoded emissions are available in the literature. However, one problem with coding these emission factors lies with their associated source rate units, which because they are not compatible with the NEDS source rate units, cannot be directly entered into HATREMS. A method to alleviate this discrepancy in units is to require reporting of all emission factors in NEDS source rate units.

Another factor which hinders HATREMS from providing complete inventories is the fact that not all of the hazardous pollutant sources can be associated with NEDS SCCs. NEDS should be continually updated until virtually all the hazardous pollutant sources are coded into the system.

C. Updating Hatrems

The HATREMS input data base will need to be periodically updated to incorporate new input data which improve the accuracy of the HATREMS emission inventories. Any data which are judged more reliable than that in the existing data base should be added into HATREMS.

The following steps in the emission inventory calculation scheme need to be periodically checked and updated for input data accuracy.

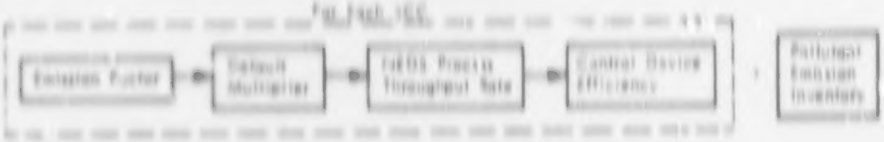
For Each SCC
Emission Factor
Default Multiplier
NEDS Process Throughput Rate
Control Device Efficiency
Pollutant Emission Inventory

TABLE 16

PERCENTAGE OF CODED HATREMS EMISSIONS

Pollutant	Estimated Annual Emissions (tons/year)	Bibliography Reference	HATREMS Coded Emissions (tons/year)	% Coded in HATREMS
Ammonia	1,272,500	80[a]	700,000	55
Arsenic	9,415	1[b]	5,471	58
Asbestos	6,579	2[a]	577	9
Barium	15,420	3[a]	4,077	26
Beryllium	164	4[a]	159	97
Boron	11,003	5[a]	4,720	43
Cadmium	2,480	6[a]	1,241	50
Chlorine[d]	678,200	80[a]	643,000	95
HCl[e]	307,600	80[a]	25,400	8
Chromium	39,774	7[b]	9,070	23
Copper	13,680	8[a]	3,840	28
Fluoride	163,140	80[a]	84,800	52
Hydrogen fluoride	14,400	[f]	12,000	83
Hydrogen sulfide	308	[f]	216	70
Lead	325,400	[g]	318,910	98
Magnesium	75,400	10[c]	60,085	80
Manganese	19,000	11[a]	10,456	55
Mercury	840	12[b]	501	60
Molybdenum	990	13[c]	639	65
Nickel	6,177	14[a]	5,070	82
Phosphorus	160,300	15[c]	76,142	47
POM	4,784,318	80[a]	2,261,142	47
Selenium	986	16[a]	695	70
Silver	417	17[c]	57	14
Titanium	88,351	18[c]	73,750	83
Vanadium	19,219	19[a]	18,750	98
Zinc	159,922	20[a]	13,160	8
Total	8,167,583		4,326,014	53

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[a] Includes uncontrolled and controlled emission sources.
[b] Uncontrolled emissions.
[c] Controlled emissions.
[d] Includes all chlorine-compound coal combustion emissions.
[e] Excludes coal combustion emissions.
[f] Controlled emissions, obtained from Reference 3.
[g] Calculated from Table 20.

First, any new, reliable source test data for any hazardous pollutant should be compared with the existing data base emission factors. Only test data should be considered which were generated from a representative source within a particular SCC category rather than from an atypical operation. The method and accuracy of the testing should be fully documented to provide a basis for its credibility. New test data may be supplied by (a) air quality control agencies, (b) industrial organizations, or (c) research and development contractors. Increased source testing of hazardous pollutant sources should be performed on all pollutants of national concern.

Default multipliers should also be periodically updated. Any new data that would alter a default multiplier should be typical for a SCC process category and the method of deriving the factor should be well documented. Industrial test data on the constituents of process feed materials for source operations which emit hazardous pollutants should be used in updating default multipliers. Given pollutant concentrations in the feed material, pollutant mass balances could be compared with source testing data to better understand the emission process.

Within HATREMS, the control device efficiencies are not adequately quantified. This input data category currently has a great potential for improvement. Information on true collection efficiencies for the hazardous pollutants should be generated from source/control device testing. The control devices tested should be indicative of typical processes and controls within a given SCC category. The test methods should be fully documented to support the credibility of the results.

Since HATREMS depends on the NEDS SCC categories, it is imperative that all possible emitting sources are included in NEDS. Currently, this is not the case. During the search for emissions information to be included in HATREMS, it was found that a number of SCC categories were either too general or too specific for the emission factors reported in the literature. To alleviate this problem, the emission factors were apportioned into existing SCCs or new SCCs were initiated. As more information is collected pertaining to the sources of hazardous pollutants, the potential for updating the SCC categories increases. By including and updating all possible sources within NEDS/HATREMS, the reliability and completeness of their resultant emission inventories will be improved.

B. Recommendations

HATREMS provides a mechanism for storing emission data and generating emissions inventory information. Included within the system are not only emission factor/source information but also supportive data such as (a) emission factor reliability codes, (b) physical state of the pollutant, (c) date of inclusion into the system, (d) literature reference of the coded information, and (e) any comments or assumptions which were incorporated into the derivation of the coded material. This additional coded information supports the input data entered into the system.

The following sections discuss recommendations/modifications to HATREMS.

1. SCC refinement: Both NEDS and HATREMS depend on the SCCs as the building blocks for the classification of coded emissions data. SCCs are continually being updated to reflect changes in emission factors, and any additions/deletions pertaining to the emitting process sources. However, some of the source categories are vague, and it is unclear as to what processes they cover. Examples include the many "general" SCC categories, such as (a) 3-01-014-01, Paint Manufacturing; (b) 3-03-030-01, Zinc Smelting; or (c) 3-06-012-01, Fluid Coking. When emission factors are reported for these categories, a reviewer may not be able to decide what processes are included. It is best to change this category "General" to "Total," denoting inclusion of all sources within a particular industrial process, or to initiate only distinct codes for various process sources. Ultimately, the NEDS SCC categories will include all the nation's major emitting process point and area sources. If emission factors are reported in proper SCC units, the update of emission factors will be a minor task.

2. Control device/efficiency refinement: HATREMS bases the type and efficiency of any SCC category's control device on that data provided in the NEDS system. This means, for example, that lead particulates emitted from a municipal incinerator are assumed to be collected with equal efficiency and to possess the same size distribution as the total particulates. However, lead, like many of the hazardous pollutants emitted from combustion processes, occurs as fine particulate matter which escapes collection devices. Therefore, particulate emission control device efficiencies which are now coded for many of the HATREMS pollutants, are typically incorrect for hazardous pollutants. This will lead to inaccurate emission inventories. To alleviate this problem, HATREMS could specify the device for pollutant removal and the actual control efficiency of that device for each hazardous pollutant. This would aid in updating the control device/efficiency input data as new techniques of control are developed to specifically control fine particulate or gaseous hazardous pollutants.

3. Recommended pollutants to load into HATREMS: Since HATREMS is a new system for storing and generating emission inventory information, an initial set of pollutants should be selected for inclusion into the system. The scope of this project has been to develop an emissions data base for 28 selected hazardous pollutants. For reasons expressed in the previous sections, not all of these pollutants are currently coded to the extent necessary to provide accurate and complete emission inventories. The following text explains the criteria for selection of the pollutants which should be entered into HATREMS.

The recommended criteria for pollutant selection are: (a) completeness of coded emission process sourcew for a given pollutant; (b) reliability of the emission factor input data; and (c) relative magnitude of the toxicity associated with the pollutant. Initially, it is recommended that beryllium, chlorine, lead, and vanadium should be placed into the active HATREMS file because they meet the above criteria.

In order to generate a complete emissions inventory for a selected pollutant, a high percentage of the emissions for that pollutant should be coded into HATREMS. As shown in Table 16, only four pollutants have a high percentage of emissions adequately coded. These are beryllium (97%), chlorine (95%), lead (98%), and vanadium (98%). Other pollutants for which greater than 70% of emissions are coded include: hydrogen sulfide (70%); hydrogen fluoride (83%); magnesium (80%); nickel (82%); and titanium (83%). As a higher percentage of pollutant emissions are coded, other pollutants should be considered for inclusion in HATREMS.

The reliability of the coded emission information is a second criteria for determining whether a pollutant is acceptable for inclusion in HATREMS. Approximately 95% of the nation's beryllium emissions and 88% of the chlorine emissions result from combustion sources (i.e., power generation stations). These coded emission data are considered to have average reliability (i.e., based on limited data and/or published emission factors where the accuracy is not stated). In addition, emissions results for the numerous lead emitting sources are fairly well documented; thus, reliability codes for lead are above average or average. The majority of the nation's vanadium emissions are from the combustion of coal and oil. This coded information for vanadium is stated to be of average reliability. As previously indicated, the verification of the accuracy of emission factor input data is lacking for the hazardous pollutants. Currently, average reliability for the HATREMS input data is regarded as adequate. As more information is gathered on these hazardous pollutants, the reliability of the coded information should increase.

The final criterion for selecting pollutants to be entered into HATREMS is the consideration of the relative toxicity levels of the various pollutants. Those pollutants deemed the most toxic should be given a higher priority. A relative toxicity scale, based on pollutant TLV concentrations, is presented in Table 17. From the table it is evident there is a wide range of toxicity levels for these hazardous pollutants. The four pollutants determined suitable for input into HATREMS have relatively high toxicity levels based on the TLV concentrations.

TABLE 17

RELATIVE TOXICITY OF HATREMS POLLUTANTS

Pollutant	Annual Emissions (tons/yr) ÷ TLV® (mg/m^3)[a]
Polycyclic organic material	4.8×10^9
*Lead	2,170,000
*Chlorine	226,000
Phosphorus	160,300
Zinc	159,900
*Beryllium	82,000
Chromium	79,500
Ammonia	70,700
Fluoride	65,300
Nickel	61,800
Cadmium	45,900
Hydrogen chloride	43,900
Silver	41,700
*Vanadium	38,500
Barium	30,800
Arsenic	18,800
Mercury	16,800
Copper	13,700
Titanium	8,800
Hydrogen fluoride	7,200
Selenium	5,000
Manganese	3,800
Magnesium	1,900
Boron	1,100
Molybdenum	198
Hydrogen sulfide	21
Asbestos[b]	-

Note: * Indicates pollutant recommended for input into HATREMS.

[a] TLVs® Threshold Limits Values (milligrams per cubic meter): time weighted average concentration for a normal 8-hr work day or 40-hr work week. American Conference of Governmental Industrial Hygienists (1976).

[b] TLV given in different concentration units so relative toxicity could not be ascertained.

IX. ANALYSIS OF EMISSION FACTOR INPUT INTO EHIS

Task VIII began with a complete familiarization with the National Air Data Branch documentation on the NEDS Emissions History Information System[14,15] and the Aerometric and Emissions Reporting System.[17] MRI performed a detailed review of the system logic, design and assumptions of the NEDS Emissions History Information System.

The Emissions History Information System was developed to (a) provide historical trends information on nationwide emissions and (b) produce synopses of air pollutant emissions. The primary use of the system will be the former; other anticipated uses are control strategy evaluation and emissions projections. Noncriteria pollutant summaries would be beneficial in determining long-range trends in addition to current emissions status.

EHIS data tabulations have been developed for the five criteria pollutants (carbon monoxide, particulates, sulfur oxides, hydrocarbons, and nitrogen oxides) for 1973.[15] These tables present (a) summaries of emissions for primary and secondary source categories, similar to those specified in the 1972 National Emissions Report,[16] and (b) summaries of production/consumption quantities and emission factors for specific source categories. The primary source categories are:

1. Transportation,

2. Fuel combustion for stationary sources,

3. Industrial processes,

4. Solid waste disposal, and

5. Miscellaneous.

Each of these categories is broken down into appropriate component secondary source categories.

EHIS input data include production or consumption rate and activity level for each type source, emission factor, and control device information. Output consists of tables of estimated annual emissions for each source category on a national basis.

EHIS is designed to provide for: (a) simple input modification, (b) automatic updating of production/consumption data, and (c) output suitable for document printing.

The following are some of the more important aspects of the system.

1. Text and table files are separate.

2. Text is standardized, so that references to emissions estimates are made through table referencing.

3. Table structure is standardized.

A. Lead Data Compilation

The feasibility of utilizing this system to produce emissions inventories and corresponding text was evaluated for lead.

Data compiled on lead for Appendix B of this project was used for this evaluation. Lead emission factors, as coded in the HATREMS system, are presented in Table 18 by EHIS source category.

As part of this evaluation, an analysis of the tables in a 1973 EHIS computer printout[157] was performed. Table 19 presents a summary of the processing types (i.e., calculation procedures) and interrelationships between EHIS particulate Tables 2.1 through 2.25. Similar processing types were designated for lead tables.

The following three major problems arise in utilizing EHIS to produce emissions inventories for lead or other noncriteria pollutants:

1. Emission factor units for a given tabulation need to be specified consistently as mass of emissions per unit of production or mass per unit of consumption. In several cases sufficient data are not available to provide for derivation of the conversion factor. In addition, it is not known whether the production rate or consumption rate is obtainable for new source categories to be input into the system on an annual basis.

2. The specific source categories used for EHIS tabulations of the five criteria pollutants are combinations of several Source Classification Codes (SCCs) and assumptions for combining emission factors are not indicated.

TABLE 18

LEAD EMISSION FACTORS[a]

A. Transportation	Emission Factor[b]	Units
Gasoline		
Light Duty Vehicles (A)	1.65 Y[c]	lb/10^3 gal.
Heavy Duty Vehicles (A)	1.65 Y[c]	lb/10^3 gal.
Off Highway Vehicles (A)	1.65 Y[c]	lb/10^3 gal.
B. Fuel Combustion		
Residential Fuel (A)		
Anthracite Coal	0.00009	lb/ton burned
Bituminous Coal	0.00002	lb/ton burned
Distillate Oil	1.2×10^{-7}	lb/10^3 gal.
Residual Oil	1.6×10^{-6}	lb/10^3 gal.
Electric Generation (P)		
Anthracite Coal	0.016	lb/ton burned
Bituminous Coal	0.016	lb/ton burned
Lignite Coal	0.011	lb/ton burned
Residual Oil	0.00016	lb/10^3 gal.
Distillate Oil	0.00012	lb/10^3 gal.
Industrial Fuel (P) and (A)		
Anthracite Coal	0.016	lb/ton burned
Bituminous Coal	0.016	lb/ton burned
Lignite Coal	0.011	lb/ton burned
Residual Oil	0.00016	lb/10^3 gal.
Distillate Oil	0.00012	lb/10^3 gal.
Commercial/Institutional Fuel (P) and (A)		
Anthracite Coal	0.016	lb/ton burned
Bituminous Coal	0.016	lb/ton burned
Lignite Coal	0.011	lb/ton burned
Residual Oil	0.00016	lb/10^3 gal.
Distillate Oil	0.00012	lb/10^3 gal.

TABLE 18 (continued)

G. Industrial Processes	Emission Factor	Units
1. Primary Metals		
Coke Met. By-Product (General)	0.035	lb/ton coal charged
Copper Smelter (Total/General)	4.0	lb/ton concentrated ore
Roasting	6.9	lb/ton concentrated ore
Converting	2.6	lb/ton concentrated ore
Reverberatory Furnace	1.7	lb/ton concentrated ore
Ferro Alloy Open Furnace		
Silicon Metal	0.0016	lb/ton produced
Silicomanganese	0.85	lb/ton produced
Ferro Alloy Semi-Covered Furnace		
Ferro Manganese	0.41	lb/ton produced
Blast Furnace	3.7	lb/ton produced
Iron Production		
Blast Furnace - Ore Charging	0.091	lb/ton produced
Blast Furnace - Agglomerate Charging	0.033	lb/ton produced
Sintering (General)	0.013	lb/ton produced
Steel Production		
Open Hearth, O_2 Lance	0.1	lb/ton produced
Open Hearth, No Lance	0.2	lb/ton produced
BOF (General)	0.2	lb/ton produced
Electric Arc, With Lance	0.04	lb/ton produced
Electric Arc, No Lance	0.22	lb/ton produced

TABLE 18 (continued)

C. Industrial Processes (continued)	Emission Factor	Units
Lead Smelters		
Sintering	174.2	lb/ton produced
Blast Furnace	58.8	lb/ton produced
Reverberatory Furnace	4.8	lb/ton produced
Ore Crushing	0.13	lb/ton concentrated ore
Total (General)[d/]	5.0	lb/ton produced
Zinc Smelting		
Roasting	26.0	lb/ton processed
Sintering	38.5	lb/ton product
Horizontal Retorts	2.4	lb/ton processed
Vertical Retorts	4.5	lb/ton processed
F. Secondary Metals		
Brass and Bronze Melting		
Rotary Furnace[d/]	0.1	lb/ton charged
Crucible[d/]	0.04	lb/ton charged
Electric Induction[d/]	0.04	lb/ton charged
Reverberatory Furnace[d/]	0.1	lb/ton charged
Gray Iron		
Cupola	0.6	lb/ton metal product
Reverberatory Furnace	0.07	lb/ton metal product
Electric Induction	0.05	lb/ton metal product
Lead Smelter Secondary		
Reverberatory Furnace	53.0	lb/ton lead produced
Blast/Cupola Furnace	56.0	lb/ton lead produced
Refining Kettle	0.21	lb/ton lead produced

TABLE 18 (continued)

C. Industrial Processes (continued)	Emission Factor	Units
Lead Oxide Production		
Barton Pot	0.44	lb/ton lead produced
Barton Pot	0.47	lb/ton lead processed
Calcining Furnace	14.0	lb/ton lead product
Lead Battery		
Total (General)	8.0	lb/ton lead processed
Casting Furnace	0.25	lb/10^3 batteries produced
Paste Mixer	2.71	lb/10^3 batteries produced
Lead Oxide Mill	2.9	lb/10^3 batteries produced
Lead Reclaim Furnace	0.1	lb/10^3 batteries produced
Small Parts Casting	0.1	lb/10^3 batteries produced
Grid Casting	0.44	lb/10^3 batteries produced
Stacking, Burning, and Assembly	1.71	lb/10^3 batteries produced
Miscellaneous Casting and Fabrication		
Cable Covering - Melting Kettle	0.5	lb/ton processed
Ammunition	1.0	lb/10^3 ton processed
Type Metal	0.25	lb/ton lead processed
Metallic Lead	1.5	lb/ton lead processed
Lead Solder Melt Pot	0.03 to 2.0	lb/ton solder melted

TABLE 18 (continued)

C. Industrial Processes (continued)	Emission Factor	Units
3. Mineral Products		
Mining (lead Ores)		
Primary Crusher	0.16	lb/ton processed
Other	0.2	lb/ton processed
Cement Manufacturing (Dry)		
Total/General	0.15	lb/ton cement produced
Kiln/Cooler	0.11	lb/ton cement produced
Dryers/Grinders	0.04	lb/ton cement produced
Cement Manufacturing (Wet)		
Total/General	0.12	lb/ton cement produced
Clinker Cooler [d]	5×10^{-5}	lb/ton cement produced
Finishing Mill [d]	1×10^{-3}	lb/ton cement produced
Kiln/Cooler	0.10	lb/ton cement produced
Dryers/Grinders	0.02	lb/ton cement produced
Glass Manufacturing		
Lead-Glass (General)	5.0	lb/ton glass produced

TABLE 18 (concluded)

C. Industrial Processes (concluded)	Emission Factor	Units
4. Petroleum Industry		
Lead Alkyl Manufacturing		
Electrolytic Process	1.0	lb/ton product
Sodium Lead Alloy Process	20.0	lb/ton processed
Process Vents, TEL	4.0	lb/ton product
Process Vents, TML	150.0	lb/ton product
Sludge Pits	1.2	lb/ton product
Recovery Furnace	55.0	lb/ton product
D. Solid Waste		
Municipal Incineration		
Multiple Chamber	0.4	tons burned
Single Chamber	0.4	tons burned
Auxiliary Fuel		
Residual Oil[e]	40.0 M	10^3 gal.
Distillate Oil[e]	40.0 M	10^3 gal.

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[a] A = area source
P = point source

[b] Uncontrolled unless otherwise specified.

[c] Y = lead content in g/gal. Resultant emission factor unit is lb/10^3 gal. of gasoline. Average 1975 lead content was 1.7 g/gal.

[d] Controlled emission factor.

[e] M = percent lead in waste oil; average = 1%.

TABLE 19

ANALYSIS OF PARTICULATE TABLES

EMIS Table No.	EMIS Processing Type[a]	Data from Table(s)	Data to Table(s)
0.1	01	2.1	
0.2	01	0.1	
2.1	02	2.3 to 2.8, 2.16 to 2.19	0.1
2.2	02	2.1	
2.3	03		2.1
2.4	05		2.1
2.5	05		2.1
2.6	08		2.1
2.7	05		2.1
2.8	07		2.1, 2.15
2.9	07		2.15
2.10	05		2.16, 2.15
2.11	05		2.16, 2.15
2.12	05		2.16, 2.15
2.13	05		2.15
2.14	06	2.10, 2.11, 2.12	
2.15	03	2.8 to 2.13	
2.16	11	2.20 to 2.25	2.1
2.17	06		2.1
2.18	09		2.1
2.19	05		2.1
2.20	12		2.16
2.21	10		2.16
2.22	10		2.16
2.23	10		2.16
2.24	10		2.16
2.25	10		2.16

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[a] Processing Type

01 : Document Summary Table
Total all fields and construct metric table
02 : Chapter Summary Table
Total field one, calculate percentage for each line and place in field two and construct metric table
03 : Add all but the last field and place result in the last field
04 : Multiply all fields but last divide by 2 and place the result in the last field
05 : Same as 04 but divide by 2,000
06 : Table 2.14 special multi-table processing
Add all fields to last, add all columns and carry results down to second table
07 : Field one times field two divided by 2, times (field three subtracted from one), place result in field four
08 : Same as 07 except divide by 2,000
09 : Field one times field two equals field three. Field three times field four divided by 2,000 results in field five
10 : Field one times field two divided by 2,000 equals field three. Field three times (field four subtracted from one) equals field five
11 : Summation of all lines for all fields
12 : Same as 10 divided by 2

3. Referencing of emission factors and production/consumption rates is not clearly documented.

The aforementioned problems decrease the reliability of the EHIS reported emissions. Emission factors which are not in the correct units have to be ignored. In addition, lead was assumed to have the same characteristic emissions as particulates. Thus, lead emission factors for some source categories were apportioned by the same methodology as particulate emission factors, if the apportioning methodology could be derived.

B. Summary

Example text and calulation routines were needed to load the selected pollutant into EHIS. A skeleton table file containing emission factors and control efficiencies was constructed for lead on the basis of emission factors developed in Tasks III through V. These data, along with the example text and calculation procedures required to develop emissions estimates, were supplied to the project officer.

Table 18 presented emission factors for lead which represent approximately 95% of the total national lead emissions. In comparison, the data tabulated for EHIS represented approximately 80% of the total lead emissions. This decrease is attributable to problems in compatibility of the emission factors.

X. OVERALL PROGRAM DISCUSSION

A. Accomplishments

A major objective of this program was to develop an emission factor data base for HATREMS. This objective was accomplished by the compilation of available point, area, and "free" area source data for each of 27 pollutants (see Summary). Appendix A presents example coded data for lead (for point and area sources) and selected coded data for "free" area sources.

Related secondary objectives were to prepare the data for loading into HATREMS and evaluate emission inventory information from HATREMS and EHIS. To achieve these objectives, the following specific tasks were accomplished:

- Area and "free" area source data were keypunched and verified.
- Methodology was developed for evaluating HATREMS emission inventories.
- Review of the major problems associated with HATREMS data base was performed.
- Lead data were compiled for EHIS.

The second major accomplishment of this program was the preparation of three chapters for inclusion in Emission Factors for Trace Substances.[2] These chapters (for lead, fluorides, and HCl/chlorine) present data compiled throughout the program. These three special report chapters are included herein as Appendices B, C, and D.

B. Recommendations

The following suggestions for future efforts are made based on the results of this project:

1. A select few pollutants should be initially entered into HATREMS for evaluation. Based on the selection criteria presented in Section VIII, four pollutants (beryllium, chlorine, lead, and vanadium) are recommended for consideration.

2. Emissions inventories should be generated for the selected pollutants on a nationwide level and possibly for several individual states

or AQCRs. The output inventories should be reviewed for completeness and accuracy as also described in Section VIII.

A format for evaluating the emissions output from HATREMS (by pollutant/SCC or by pollutant and combination of SCCs) is presented in Appendix E. The primary use of this evaluation form would be to compare emissions as output from HATREMS (based on HATREMS emission factor data and NEDS process data) with HATREMS emission factor data and non-NEDS process data. A sample data sheet presenting lead emissions from copper smelter roasting operations is provided in Appendix E. Table 20 presents calculated uncontrolled lead emissions based on HATREMS emission factors and non-NEDS process throughput data. Comparison of Table 20 (and assuming average control efficiences from NEDS) with HATREMS lead output will give the evaluator an indication of what percentage of the emissions of a pollutant are covered in the NEDS system.

In addition, the HATREMS output can be compared with calculated emissions based on: (a) non-HATREMS emission factors and non-NEDS process data; or (b) non-HATREMS emission factors and NEDS process data. These latter comparisons will determine whether or not revisions should be made to the HATREMS emission factor data.

TABLE 29

UNCONTROLLED LEAD EMISSIONS

SCC Code	Process Description	NATIEMS Coded Emission Factor^a/	NATIEMS Coded Default Multiplier	Non-NEDS Annual Process Throughput	Emission Units	Annual Emissions (tons/yr)
I. Point Sources						
A. Electrical Generation						
1. Anthracite coal						
10100101	> 100 MM Btu Pulvrizd	0.0018	9.0^a/	1,460,000^b/	Tons burned	12
10100102	> 100 MM Btu Stokers	0.0018	9.0^a/		Tons burned	
10100103	10-100 MM Btu Pulvd	0.0018	9.0^a/		Tons burned	
10100104	10-100 MM Btu Stokers	0.0018	9.0^a/		Tons burned	
10100105	<10 MM Btu Pulvd	0.0018	9.0^a/		Tons burned	
10100106	<10 MM Btu Stoker	0.0018	9.0^a/		Tons burned	
10100199	Other/Not Classifd	0.0018	9.0^a/		Tons burned	
2. Bituminous coal						
10100201	> 100 MM Btu Pulv Wet	0.0018	9.0^a/	372,598,000^b/	Tons burned	3,018
10100202	> 100 MM Btu Pulv Dry	0.0018	9.0^a/		Tons burned	
10100203	> 100 MM Btu Cyclone	0.0018	9.0^a/		Tons burned	
10100204	> 100 MM Btu Spd Stk	0.0018	9.0^a/		Tons burned	
10100205	> 100 MM Btu/Hr OFSK	0.0018	9.0^a/		Tons burned	
10100206	10-100 MM Btu. Pul wt	0.0018	9.0^a/		Tons burned	
10100207	10-100 MM Btu Pul dy	0.0018	9.0^a/		Tons burned	
10100208	10-100 MM Btu. Of stk	0.0018	9.0^a/		Tons burned	
10100209	10-100 MM Btu Ufstk	0.0018	9.0^a/		Tons burned	
10100210	< 10 MM Btu Ofstoker	0.0018	9.0^a/		Tons burned	
10100211	< 10 MM Btu Ufstoker	0.0018	9.0^a/		Tons burned	
10100212	< 10 MM Btu Pulv-Dry	0.0018	9.0^a/		Tons burned	
10100299	Other/Not Classifd	0.0018	9.0^a/		Tons burned	

TABLE 29 (continued)

SCC Code	Process Description	I-TRENDS Coded Emission Factor[a]	I-TRENDS Coded Default Multiplier	Non-NEDS Annual Process Throughput	Emission Units	Annual Emissions (tons/yr)
	3. Lignite					
10100301	>100 MM Btu Pulwet	0.0018	6.0[a]	12,500,000[b]	Tons burned	68
10100302	>100 MM Btu Puldry	0.0018	6.0[a]		Tons burned	
10100303	>100 MM Btu Cyclone	0.0018	6.0[a]		Tons burned	
10100304	>100 MM Btu Ofstk	0.0018	6.0[a]		Tons burned	
10100305	>100 MM Btu Ufstk	0.0018	6.0[a]		Tons burned	
10100306	>100 MM Btu Spdstk	0.0018	6.0[a]		Tons burned	
10100307	10-100 MM Btu DyPul	0.0018	6.0[a]		Tons burned	
10100308	10-100 MM Btu WtPul	0.0018	6.0[a]		Tons burned	
[illegible]	10-100 MM Btu Ofstk	0.0018	6.0[a]		Tons burned	
[illegible]	10-100 MM Btu Ufstk	0.0018	6.0[a]		Tons burned	
[illegible]	10-100 MM Btu Spdstk	0.0018	6.0[a]		Tons burned	
[illegible]	<10 MM Btu Pulv dry	0.0018	6.0[a]		Tons burned	
[illegible]	<10 MM Btu Of stk	0.0018	6.0[a]		Tons burned	
[illegible]	<10 MM Btu Uf stk	0.0018	6.0[a]		Tons burned	
[illegible]	<10 MM Btu Spdstk	0.0018	6.0[a]		Tons burned	
	4. Residual oil					
[illegible]	>100 MM Btu/Hr Genl	0.004	0.04[b]	19,504,073[b]	1,000 gal. burned	2
[illegible]	10-100 MM Btu/Hr Genl	0.004	0.04[b]		1,000 gal. burned	
[illegible]	<10 MM Btu/Hr Genl	0.004	0.04[b]		1,000 gal. burned	
	5. Distillate oil					
[illegible]	>100 MM Btu/Hr Genl	0.004	0.003[b]	1,117,817[b]	1,000 gal. burned	negligible
[illegible]	10-100 MM Btu/Hr Genl	0.004	0.003[b]		1,000 gal. burned	
[illegible]	<10 MM Btu/Hr Genl	0.004	0.003[b]		1,000 gal. burned	

TABLE 35 (continued)

SCC Code	Process Description	HATREMS Coded Emission Factor$^{a/}$	HATREMS Coded Default Multiplier	Non-NEDS Annual Process Throughput	Emission Units	Annual Emissions (tons/yr)
	3. Industrial					
	1. Anthracite coal					
10200101	>100 MM Btu/Hr Pulv	0.0018	9.0$^{b/}$	364,000$^{c/}$	Tons burned	3
10200102	>100 MM Btu/Hr Stk	0.0018	9.0$^{b/}$		Tons burned	
10200103	10-100 MM Btu Pulvd	0.0018	9.0$^{b/}$		Tons burned	
10200104	10-100 MM Btu Stk	0.0018	9.0$^{b/}$		Tons burned	
10200105	<10 MM Btu/Hr Pulvd	0.0018	9.0$^{b/}$		Tons burned	
10200106	<10 MM Btu/Hr Stk	0.0018	9.0$^{b/}$		Tons burned	
10200107	<10 MM Btu/Hr Hndfr	0.0018	9.0$^{b/}$		Tons burned	
10200199	Other/Not Clasifd	0.0018	9.0$^{b/}$		Tons burned	
	2. Bituminous coal					
10200201	>100 MM Btu Pulvwet	0.0018	9.0$^{b/}$	62,928,000$^{c/}$	Tons burned	510
10200202	>100 MM Btu Pulvdry	0.0018	9.0$^{b/}$		Tons burned	
10200203	>100 MM Btu Cyclone	0.0018	9.0$^{b/}$		Tons burned	
10200204	>100 MM Btu Spdstk	0.0018	9.0$^{b/}$		Tons burned	
10200205	10-100 MM Btu Ofstk	0.0018	9.0$^{b/}$		Tons burned	
10200206	10-100 MM Btu Ufstk	0.0018	9.0$^{b/}$		Tons burned	
10200207	10-100 MM Btu Pulwt	0.0018	9.0$^{b/}$		Tons burned	
10200208	10-100 MM Btu Puldry	0.0018	9.0$^{b/}$		Tons burned	
10200209	10-100 MM Btu Spdstk	0.0018	9.0$^{b/}$		Tons burned	
10200210	<10 MM Btu Ofdstk	0.0018	9.0$^{b/}$		Tons burned	
10200211	<10 MM Btu Ufdstk	0.0018	9.0$^{b/}$		Tons burned	
10200212	<10 MM Btu Pulv Dry	0.0018	9.0$^{b/}$		Tons burned	
10200213	<10 MM Btu Spd Stk	0.0018	9.0$^{b/}$		Tons burned	
10200214	<10 MM Btu Handfire	0.0018	9.0$^{b/}$		Tons burned	
10200299	Other/Not Clasifd	0.0018	9.0$^{b/}$		Tons burned	

TABLE 20 (continued)

SCC Code	Process Description	MATHEWS Coded Emission Factor[a]	MATHEWS Coded Default Multiplier	Bra-NEDS Annual Process Throughput	Emission Units	Annual Emissions (tons/yr)
	3. Lignite					
10200301	>100 MM Btu PulvWet	0.0018	6.0[a]	2,866,000[c]	Tons burned	23
10200302	>100 MM Btu PulvDry	0.0018	6.0[a]		Tons burned	
10200303	>100 MM Btu Cyclone	0.0018	6.0[a]		Tons burned	
10200304	>100 MM Btu Ofstkr	0.0018	6.0[a]		Tons burned	
10200305	>100 MM Btu Ufstkr	0.0018	6.0[a]		Tons burned	
10200306	>100 MM Btu Spdstk	0.0018	6.0[a]		Tons burned	
10200307	10-100 MM Btu Dy Pulv	0.0018	6.0[a]		Tons burned	
10200308	10-100 MM Btu Wt Pul	0.0018	6.0[a]		Tons burned	
10200309	10-100 MM Btu Ofstk	0.0018	6.0[a]		Tons burned	
10200310	10-100 MM Btu Ufstk	0.0018	6.0[a]		Tons burned	
10200311	10-100 MM Btu Spdstk	0.0018	6.0[a]		Tons burned	
10200312	<10 MM Btu Pulv Dry	0.0018	6.0[a]		Tons burned	
10200313	<10 MM Btu Ofstk	0.0018	6.0[a]		Tons burned	
10200314	<10 MM Btu Ufstk	0.0018	6.0[a]		Tons burned	
10200315	<10 MM Btu Handfire	0.0018	6.0[a]		Tons burned	
10200316	<10 MM Btu Spdstk	0.0018	6.0[a]		Tons burned	
	4. Residual oil					
10200401	>100 MM Btu/Hr	0.004	0.04[b]	8,443,282[c]	1,000 gal. burned	0.68
10200402	10-100 MM Btu/Hr	0.004	0.04[b]		1,000 gal. burned	
10200403	<10 MM Btu/Hr	0.004	0.04[b]		1,000 gal. burned	
	5. Distillate oil					
10200501	>100 MM Btu/Hr	0.004	0.003[b]	3,024,840[c]	1,000 gal. burned	0.02
10200502	10-100 MM Btu/Hr	0.004	0.003[b]		1,000 gal. burned	
10200503	<10 MM Btu/Hr	0.004	0.003[b]		1,000 gal. burned	

TABLE 29 (continued)

SCC Code	Process Description	HATREMS Coded Emission Factor[a/]	HATREMS Coded Default Multiplier	Non-NEDS Annual Process Throughput	Emission Units	Annual Emissions (tons/yr)
	C. Commercial/Institutional					
	1. Anthracite coal					
10300105	10-100 MM Btu Pul Wt	0.0018	9.0[b/]	2,118,000[c/]	Tons burned	17
10300106	10-100 MM Btu Pul Dy	0.0018	9.0[b/]		Tons burned	
10300107	10-100 MM Btu Spdstk	0.0018	9.0[b/]		Tons burned	
10300108	<10 MM Btu Pulvized	0.0018	9.0[b/]		Tons burned	
10300109	<10 MM Btu Stoker	0.0018	9.0[b/]		Tons burned	
10300110	<10 MM Btu Spdstk	0.0018	9.0[b/]		Tons burned	
10300199	Other/Not Classifd	0.0018	9.0[b/]		Tons burned	
	2. Bituminous coal					
10300205	10-100 MM Btu Pulwt	0.0018	9.0[b/]	4,519,000[c/]	Tons burned	37
10300206	10-100 MM Btu Puldy	0.0018	9.0[b/]		Tons burned	
10300207	10-100 MM Btu Ofstk	0.0018	9.0[b/]		Tons burned	
10300208	10-100 MM Btu Ufstk	0.0018	9.0[b/]		Tons burned	
10300209	10-100 MM Btu Spdstk	0.0018	9.0[b/]		Tons burned	
10300210	10-100 MM Btu Hndfr	0.0018	9.0[b/]		Tons burned	
10300211	<10 MM Btu Ofstk	0.0018	9.0[b/]		Tons burned	
10300212	<10 MM Btu Ufstkr	0.0018	9.0[b/]		Tons burned	
10300213	<10 MM Btu Spdstkr	0.0018	9.0[b/]		Tons burned	
10300214	<10 MM Btu Handfire	0.0018	9.0[b/]		Tons burned	
	3. Lignite					
10300305	10-100 MM Btu Pulwt	0.0018	6.0[b/]	62,500[c/]	Tons burned	0.34
10300306	10-100 MM Btu Puldy	0.0018	6.0[b/]		Tons burned	
10300307	10-100 MM Btu Ofstk	0.0018	6.0[b/]		Tons burned	
10300308	10-100 MM Btu Ufstk	0.0018	6.0[b/]		Tons burned	
10300309	10-100 MM Btu Spdstk	0.0018	6.0[b/]		Tons burned	
10300310	<10 MM Btu Pulv Dy	0.0018	6.0[b/]		Tons burned	
10300311	<10 MM Btu Ofstk	0.0018	6.0[b/]		Tons burned	
10300312	<10 MM Btu Ufstk	0.0018	6.0[b/]		Tons burned	
10300313	<10 MM Btu Spdstk	0.0018	6.0[b/]		Tons burned	
10300314	<10 MM Btu Handfire	0.0018	6.0[b/]		Tons burned	

TABLE 20 (continued)

SCC Code	Process Description	NATHEMS Coded Emission Factor a/	NATHEMS Coded Default Multiplier	Non-NEDS Annual Process Throughput	Emission Units	Annual Emissions (tons/yr)
	4. Residual oil					
10300401	>100 MM Btu/Hr	0.004	0.04 b/	8,256,360 c/	1,000 gal. burned	0.66
10300402	10-100 MM Btu/Hr	0.004	0.04 b/		1,000 gal. burned	
10300403	<10 MM Btu/Hr	0.004	0.04 b/		1,000 gal. burned	
	5. Distillate oil					
10300501	>100 MM Btu/Hr	0.004	0.003	7,964,796 c/	1,000 gal. burned	0.55
10300502	10-100 MM Btu/Hr	0.004	0.003		1,000 gal. burned	
10300503	<10 MM Btu/Hr	0.004	0.003		1,000 gal. burned	
	B. Industrial Process					
	1. Primary metals					
30300301	Coke Met., General	0.035	-	75,514,838 d/	Tons coal charged	1,322
30300501	Copper, Total/General	4.0	-	5,500,000 d/	Tons concentrated ore	11,000
30300502	Copper, Roasting	2.3	0.3 e/	4,400,000 d/	Tons concentrated ore	1,518
30300503	Copper, Smelting	1.7	-	5,500,000 d/	Tons concentrated ore	4,675
30300504	Copper, Converting	2.6	-	5,500,000 d/	Tons concentrated ore	7,150
30300604	Feralloy Open F., Si Metal	0.0016	-	n/	Tons produced	-
30300605	Feralloy Open F., Si Mn	0.85	-	222,772 d/	Tons produced	94.7
30300701	Feralloy Sem Cov. F., Ferro Mn	0.4	-	607,497 d/	Tons produced	121.5
30300801	Iron Prod., Blast F-Ore C.	0.091	0.4625 f/	79,920,000 d/	Tons produced	2,478
30300802	Iron Prod., Blast F. Agl C.	0.033	-			1,319
30300813	Iron Prod., Sintering Gen	0.013	-	30,830,000 d/	Tons produced	200.4

TABLE 20 (continued)

SCC Code	Process Description	NATHENS Coded Emission Factor^a/	NATHENS Coded Default Multiplier	Non-NEDS Annual Process Throughput	Emission Units	Annual Emissions (tons/yr)
30300901	Steel Prod., Op. Hearth Oxl.	0.2 } 0.35^e/	-	22,160,000	Tons produced	3,878
30300902	Steel Prod., Op. Hearth No. Oxl.	0.3 }	-			
30300903	Steel Prod., BOF General	0.2	-	72,800,000^f/	Tons produced	7,280
30300904	Steel Prod., Elec. Arc W/L	0.22 } 0.36^g/	-	12,600,000^g/	Tons produced	2,268
30300905	Steel Prod., Elec Arc Wo L.	0.18 }	-			
30301001	Lead Smelters, Sintering	105.0	-	1,070,000^h/	Tons concentrated ore	56,175
30301002	Lead Smelters, Blast F	35.0	-	1,070,000^h/	Tons concentrated ore	18,725
30301003	Lead Smelters, Reverb F.	2.9	-	1,070,000^h/	Tons concentrated ore	1,552
30301004	Lead Smelters, Ore Crushing	0.13	-	9,330,000^i/	Tons Ore Crushed	606.5
30303002	Zinc Smelting, Roasting/M-H.	13.0	-	890,000^j/	Tons processed	5,785
30303003	Zinc Smelting, Sintering	19.0	-	890,000^j/	Tons processed	8,455
30303004	Zinc Smelting, Hrz. Retorts	1.2	-	62,000^j/	Tons processed	37
30303005	Zinc Smelting, Vert. Retorts	2.2	-	142,000^j/	Tons processed	156
	2. Secondary Metals					
30400206	Brass/Bronze, Rotary F.	7.0	-	m/	Tons charged	-
30400301	Gray Iron, Cupola	0.51	-	11,625,000^n/	Tons metal charge	2,964
30400302	Gray Iron, Reverb F.	0.06	-	1,020,000^n/	Tons metal charge	31
30400303	Gray Iron, Elec. Induc.	0.04	-	3,995,000^n/	Tons metal charge	80

TABLE 20 (continued)

SCC Code	Process Description	NATNEMS Coded Emission Factor$^{a/}$	NATNEMS Coded Default Multiplier	Non-NEDS Annual Process Throughput	Emission Units	Annual Emissions (tons/yr)
30400402	Lead Smelt Sec., Reverb F.	25.0	-	424,500$^{i/}$	Tons metal charged	5,306
30400403	Lead Smelt Sec., Blast/Cupola	32.0	-	570,051$^{h/}$	Tons metal charged	9,121
30400501	Lead Battery, Total/ General	0.4	-	966,500$^{h/}$	Tons of batteries produced	193
30400502	Lead Battery, Casting F.	0.0021	-	966,500$^{h/}$	Tons of batteries produced	1
30400503	Lead Battery, Paste Mixer	0.18	-	966,500$^{h/}$	Tons of batteries produced	87
	E. Solid Waste - Government					
	1. Municipal Incineration					
50100101	Multiple Chamber	0.4	-	18,200,000$^{h/}$	Tons burned	3,640
50100102	Single Chamber	0.4	-		Tons burned	
	2. Auxiliary fuel					
50190004	Residual Oil	40.0	1.0$^{d/}$	m/	1,000 gal.	-
50190005	Distillate Oil	46.0	1.0$^{d/}$	m/	1,000 gal.	
II.	Area Sources					
	A. Combustion					
01	Residential Anthracite	0.00001	9.0$^{g/}$	2,004,615$^{i/}$	Tons	0.13
02	Residential Bituminous	0.00002	4.0$^{g/}$	5,133,929$^{i/}$	Tons	0.46
03	Residential Distillate	0.00004	0.003$^{h/}$	16,300,060$^{i/}$	1,000 gal.	negligible
04	Residential Residual	0.00004	0.04$^{h/}$	m/	1,000 gal.	-
07	Comm/Inst. Anthracite	0.0018	9.2$^{g/}$	m/	Tons	
08	Comm/Inst. Bituminous	0.0018	5.0$^{g/}$	m/	Tons	
09	Comm/Inst. Distillate	0.004	0.003$^{h/}$	m/	1,000 gal.	
10	Comm/Inst. Residual	0.004	0.04$^{h/}$	m/	1,000 gal.	
13	Industrial Anthracite	0.0018	9.0$^{g/}$	m/	Tons	

TABLE 20 (Concluded)

SCC Code	Process Description	HATREMS Coded Emission Factor$^{o/}$	HATREMS Coded Default Multiplier	Non-NEDS Annual Process Throughput	Emission Units	Annual Emissions (tons/yr)
14	Industrial Bituminous	0.0018	9.0$^{a/}$	m/	Tons	
16	Industrial Distillate	0.004	0.003$^{b/}$	m/	1,000 gal.	
17	Industrial Residual	0.004	0.04$^{b/}$	m/	1,000 gal.	
21	Residential On-Site Incin.	20.0	0.217$^{e/}$		Tons	
22	Industrial On-Site Incin.	20.0	0.217$^{e/}$	30,000,000$^{k/}$	Tons	7,000
23	Comm-Inst. On-Site Incin.	20.0	0.217$^{e/}$		Tons	
39	Off Hiway Gas Vehicles	1.68	1.7$^{f/}$	2,072,000$^{h/}$	1,000 gal.	3,000
55	Unpaved Road Travel	0.0087	0.4$^{g/}$	1,948$^{h/}$	1,000 vehicle miles	0.0035
56	Unpaved Airstrips	0.00002	0.4$^{g/}$	913,020$^{i/}$	Landing/takeoff cycles	0.0036
59	Land Tilling	0.00003	0.4$^{g/}$	819,048,000$^{j/}$	Acre-tilled	4.8
AA	Light Duty Gas. Vehicles	1.65	1.7$^{f/}$	106,301,765$^{h/}$	1,000 gal.	349,900
AB	Heavy Duty Gas Vehicles	1.65	1.7$^{f/}$		1,000 gal.	
					Total	358,910

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a/ ppm Pb in coal.
b/ ppm Pb in oil.
c/ Percentage Pb in concentrated ore.
d/ Percentage by weight in fuel.
e/ Percent lead in refuge.
f/ Grams lead per gallon of gasoline.
g/ PPM lead in dust.
h/ 1974 data.
i/ 1973 data.
j/ 1975 data.
k/ 1970 data.
l/ 1969 data.
m/ Data not available.
n/ Average value.
o/ Pounds per emission unit-ppm.

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APPENDIX A

EXAMPLE HATREMS DATA

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A. Point Source Data

1. Point Source Emission Factors--Card 1. . . . . A-3 to A-28
2. SCC Emission Factor Origin (Example: Lead Noncombustion Sources. A-29 to A-30

B. Area Source Data

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1. Area Source Emission Factors--Cards 1, 2, and 3. . . A-38
2. Emission Factor Origin A-39
3. "Free" Area Source Input (Example) A-40

A. Point Source Data

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[illegible]  [illegible]  750    PPM CU IN COAL                 APP001    A3F
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[illegible]   [illegible]   [illegible]   PPM PB IN DISTILLATE OIL    [illegible]   A3F
[illegible]   [illegible]   [illegible]   PPM PB IN DISTILLATE OIL    [illegible]   A3F
[illegible]   [illegible]   [illegible]   PPM PB IN DISTILLATE OIL    [illegible]   A3F
[illegible]   [illegible]   [illegible]   PPM PB IN COAL              [illegible]   A3F
[illegible]   [illegible]   [illegible]   PPM PB IN COAL              [illegible]   A3F
[illegible]   [illegible]   [illegible]   PPM PB IN COAL              [illegible]   A3F
[illegible]   [illegible]   [illegible]   PPM PB IN COAL              [illegible]   A3F
[illegible]   [illegible]   [illegible]   PPM PB IN COAL              [illegible]   A3F
[illegible]   [illegible]   [illegible]   PPM PB IN COAL              [illegible]   A3F
[illegible]   [illegible]   [illegible]   PPM PB IN COAL              [illegible]   A3F
[illegible]   [illegible]   [illegible]   PPM PB IN COAL              [illegible]   A3F
[illegible]   [illegible]   [illegible]   PPM PB IN COAL              [illegible]   A3F
[illegible]   [illegible]   [illegible]   PPM PB IN COAL              [illegible]   A3F
[illegible]   [illegible]   [illegible]   PPM PB IN COAL              [illegible]   A3F
[illegible]   [illegible]   [illegible]   PPM PB IN COAL              [illegible]   A3F
[illegible]   [illegible]   [illegible]   PPM PB IN COAL              [illegible]   A3F
[illegible]   [illegible]   [illegible]   PPM PB IN COAL              [illegible]   A3F
[illegible]   [illegible]   [illegible]   PPM PB IN COAL              [illegible]   A3F
[illegible]   [illegible]   [illegible]   PPM PB IN COAL              [illegible]   A3F
[illegible]   [illegible]   [illegible]   PPM PB IN COAL              [illegible]   A3F
[illegible]   [illegible]   [illegible]   PPM PB IN COAL              [illegible]   A3F
[illegible]   [illegible]   [illegible]   PPM PB IN COAL              [illegible]   A3F
[illegible]   [illegible]   [illegible]   PPM PB IN COAL              [illegible]   A3F
[illegible]   [illegible]   [illegible]   PPM PB IN COAL              [illegible]   A3F
[illegible]   [illegible]   [illegible]   PPM PB IN COAL              [illegible]   A3F
[illegible]   [illegible]   [illegible]   PPM PB IN COAL              [illegible]   A3F
[illegible]   [illegible]   [illegible]   PPM PB IN COAL              [illegible]   A3F
[illegible]   [illegible]   [illegible]   PPM PB IN COAL              [illegible]   A3F
[illegible]   [illegible]   [illegible]   PPM PB IN COAL              [illegible]   A3F
[illegible]   [illegible]   [illegible]   PPM PB IN COAL              [illegible]   A3F
[illegible]   [illegible]   [illegible]   PPM PB IN COAL              [illegible]   A3F
[illegible]   [illegible]   [illegible]   PPM PB IN COAL              [illegible]   A3F
[illegible]   [illegible]   [illegible]   PPM PB IN COAL              [illegible]   A3F
[illegible]   [illegible]   [illegible]   PPM PB IN COAL              [illegible]   A3F
[illegible]   [illegible]   [illegible]   PPM PB IN COAL              [illegible]   A3F
[illegible]   [illegible]   [illegible]   PPM PB IN COAL              [illegible]   A3F
[illegible]   [illegible]   [illegible]   PPM PB IN COAL              [illegible]   A3F
[illegible]   [illegible]   [illegible]   PPM PB IN COAL              [illegible]   A3F
[illegible]   [illegible]   [illegible]   PPM PB IN COAL              [illegible]   A3F
[illegible]   [illegible]   [illegible]   PPM PB IN COAL              [illegible]   A3F
[illegible]   [illegible]   [illegible]   PPM PB IN COAL              [illegible]   A3F
[illegible]   [illegible]   [illegible]   PPM PB IN COAL              [illegible]   A3F
[illegible]   [illegible]   [illegible]   PPM PB IN RESIDUAL OIL      [illegible]   A3F
[illegible]   [illegible]   [illegible]   PPM PB IN RESIDUAL OIL      [illegible]   A3F
[illegible]   [illegible]   [illegible]   PPM PB IN RESIDUAL OIL      [illegible]   A3F
[illegible]   [illegible]   [illegible]   PPM PB IN RESIDUAL OIL      [illegible]   A3F
[illegible]   [illegible]   [illegible]   PPM PB IN DISTILLATE OIL    [illegible]   A3F
[illegible]   [illegible]   [illegible]   PPM PB IN DISTILLATE OIL    [illegible]   A3F
[illegible]   [illegible]   [illegible]   PPM PB IN DISTILLATE OIL    [illegible]   A3F
[illegible]   [illegible]   [illegible]   PPM PB IN COAL              [illegible]   A3F
[illegible]   [illegible]   [illegible]   PPM PB IN COAL              [illegible]   A3F
[illegible]   [illegible]   [illegible]   PPM PB IN COAL              [illegible]   A3F
[illegible]   [illegible]   [illegible]   PPM PB IN COAL              [illegible]   A3F
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[illegible]   [illegible]   90   PPM PB IN COAL                    [illegible]   [illegible]
[illegible]   [illegible]   90   PPM PB IN COAL                    [illegible]   [illegible]
[illegible]   [illegible]   90   PPM PB IN COAL                    [illegible]   [illegible]
[illegible]   [illegible]   90   PPM PB IN COAL                    [illegible]   [illegible]
[illegible]   [illegible]   90   PPM PB IN COAL                    [illegible]   [illegible]
[illegible]   [illegible]   90   PPM PB IN COAL                    [illegible]   [illegible]
[illegible]   [illegible]   90   PPM PB IN COAL                    [illegible]   [illegible]
[illegible]   [illegible]   90   PPM PB IN COAL                    [illegible]   [illegible]
[illegible]   [illegible]   90   PPM PB IN COAL                    [illegible]   [illegible]
[illegible]   [illegible]   90   PPM PB IN COAL                    [illegible]   [illegible]
[illegible]   [illegible]   90   PPM PB IN COAL                    [illegible]   [illegible]
[illegible]   [illegible]   90   PPM PB IN COAL                    [illegible]   [illegible]
[illegible]   [illegible]   90   PPM PB IN COAL                    [illegible]   [illegible]
[illegible]   [illegible]   60   PPM PB IN COAL                    [illegible]   [illegible]
[illegible]   [illegible]   60   PPM PB IN COAL                    [illegible]   [illegible]
[illegible]   [illegible]   60   PPM PB IN COAL                    [illegible]   [illegible]
[illegible]   [illegible]   60   PPM PB IN COAL                    [illegible]   [illegible]
[illegible]   [illegible]   60   PPM PB IN COAL                    [illegible]   [illegible]
[illegible]   [illegible]   60   PPM PB IN COAL                    [illegible]   [illegible]
[illegible]   [illegible]   60   PPM PB IN COAL                    [illegible]   [illegible]
[illegible]   [illegible]   60   PPM PB IN COAL                    [illegible]   [illegible]
[illegible]   [illegible]   60   PPM PB IN COAL                    [illegible]   [illegible]
[illegible]   [illegible]   60   PPM PB IN COAL                    [illegible]   [illegible]
[illegible]   [illegible]   004 PPM PB IN RESIDUAL OIL             [illegible]   [illegible]
[illegible]   [illegible]   004 PPM PB IN RESIDUAL OIL             [illegible]   [illegible]
[illegible]   [illegible]   004 PPM PB IN RESIDUAL OIL             [illegible]   [illegible]
[illegible]   [illegible]   0003PPM PB IN DISTILLATE OIL           [illegible]   [illegible]
[illegible]   [illegible]   0003PPM PB IN DISTILLATE OIL           [illegible]   [illegible]
[illegible]   [illegible]   0003PPM PB IN DISTILLATE OIL           [illegible]   [illegible]
[illegible]   [illegible]   10   NONE                              [illegible]   [illegible]
[illegible]   46            10   NONE                              [illegible]   [illegible]
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[illegible]   17            10   NONE                              [illegible]   [illegible]
[illegible]   [illegible]   10   NONE                              [illegible]   [illegible]
[illegible]   [illegible]   10   NONE                              [illegible]   [illegible]
[illegible]   [illegible]   10   NONE                              [illegible]   [illegible]
[illegible]   [illegible]   10   NONE                              [illegible]   [illegible]
[illegible]   [illegible]   10   NONE                              [illegible]   [illegible]
[illegible]   [illegible]   10   NONE                              [illegible]   [illegible]
[illegible]   [illegible]   10   NONE                              [illegible]   [illegible]
[illegible]   [illegible]   10   NONE                              [illegible]   [illegible]
[illegible]   [illegible]   10   NONE                              [illegible]   [illegible]
[illegible]   [illegible]   10   NONE                              [illegible]   [illegible]
[illegible]   [illegible]   10   NONE                              [illegible]   [illegible]
[illegible]   [illegible]   10   NONE                              [illegible]   [illegible]
[illegible]   [illegible]   10   NONE                              [illegible]   [illegible]
[illegible]   350           10   NONE                              [illegible]   [illegible]
[illegible]   29            10   NONE                              [illegible]   [illegible]
[illegible]   [illegible]   10   NONE                              [illegible]   [illegible]
[illegible]   140           10   NONE                              [illegible]   [illegible]
[illegible]   [illegible]   10   NONE                              [illegible]   [illegible]
[illegible]   12            10   NONE                              [illegible]   [illegible]
[illegible]   22            10   NONE                              [illegible]   [illegible]
[illegible]   73            10   NONE                              [illegible]   [illegible]
[illegible]   [illegible]   10   NONE                              [illegible]   [illegible]
[illegible]   [illegible]   10   NONE                              [illegible]   [illegible]
[illegible]   [illegible]   10   NONE                              [illegible]   [illegible]
[illegible]   280           10   NONE                              [illegible]   [illegible]
[illegible]   420           10   NONE                              [illegible]   [illegible]
[illegible]   [illegible]   10   NONE                              [illegible]   [illegible]
[illegible]   [illegible]   10   NONE                              [illegible]   [illegible]
[illegible]   [illegible]   10   NONE                              [illegible]   [illegible]
[illegible]   [illegible]   10   NONE                              [illegible]   [illegible]
[illegible]   [illegible]   10   NONE                              [illegible]   [illegible]
[illegible]   400           10   PERCENTAGE BY WEIGHT IN FUEL      [illegible]   [illegible]
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[illegible]   500        10  PERCENTAGE BY WEIGHT IN FUEL 1PP 1      A3F
[illegible]   170       008  PERCENTAGE HG IN COAL       1PP001      A3F
[illegible]    20       008  PERCENTAGE HG IN COAL       1PP001      A3F
[illegible]   170       008  PERCENTAGE HG IN COAL       1PP001      A3F
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[illegible]   170       008  PERCENTAGE HG IN COAL       1PP001      A3F
[illegible]    20       008  PERCENTAGE HG IN COAL       1PP001      A3F
[illegible]   170       008  PERCENTAGE HG IN COAL       1PP001      A3F
[illegible]   130       008  PERCENTAGE HG IN COAL       1PP001      A3F
[illegible]   170       008  PERCENTAGE HG IN COAL       1PP001      A3F
[illegible]    20       008  PERCENTAGE HG IN COAL       1PP001      A3F
[illegible]   130       008  PERCENTAGE HG IN COAL       1PP001      A3F
[illegible]    50       008  PERCENTAGE HG IN COAL       1PP001      A3F
[illegible]   130       008  PERCENTAGE HG IN COAL       1PP001      A3F
[illegible]   170       008  PERCENTAGE HG IN COAL       1PP001      A3F
[illegible]    50       008  PERCENTAGE HG IN COAL       1PP001      A3F
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[illegible]    20       008  PERCENTAGE HG IN COAL       1PP001      A3F
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[illegible]   170       008  PERCENTAGE HG IN COAL       1PP001      A3F
[illegible]   160       008  PERCENTAGE PB IN COAL       1PP001      A3F
[illegible]    65       005  PERCENTAGE HG IN COAL       1PP001      A3F
[illegible]    65       005  PERCENTAGE HG IN COAL       1PP001      A3F
[illegible]    65       005  PERCENTAGE HG IN COAL       1PP001      A3F
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[illegible]    65       005  PERCENTAGE HG IN COAL       1PP001      A3F
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[illegible]    65       005  PERCENTAGE HG IN COAL       1PP001      A3F
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[illegible]    65       005  PERCENTAGE HG IN COAL       1PP001      A3F
[illegible]    65       005  PERCENTAGE HG IN COAL       1PP001      A3F
[illegible]    65       005  PERCENTAGE HG IN COAL       1PP001      A3F
[illegible]    65       005  PERCENTAGE HG IN COAL       1PP001      A3F
[illegible]    0018      15  PPM HG IN RESIDUAL OIL      1PP001      A3F
[illegible]    0018      15  PPM HG IN RESIDUAL OIL      1PP001      A3F
[illegible]    0018      15  PPM HG IN RESIDUAL OIL      1PP001      A3F
[illegible]   170       008  PERCENTAGE HG IN COAL       1PP001      A3F
[illegible]    20       008  PERCENTAGE HG IN COAL       1PP001      A3F
[illegible]   170       008  PERCENTAGE HG IN COAL       1PP001      A3F
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[illegible]   170       008  PERCENTAGE HG IN COAL       1PP001      A3F
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[illegible]   100       008  PERCENTAGE HG IN COAL       1PP001      A3F
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[illegible]   140       008  PERCENTAGE HG IN COAL       1PP001      A3F
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[illegible]    50       008  PERCENTAGE HG IN COAL       1PP001      A3F
[illegible]   130       008  PERCENTAGE HG IN COAL       1PP001      A3F
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[illegible]    50       008  PERCENTAGE HG IN COAL       1PP001      A3F
[illegible]   130       008  PERCENTAGE HG IN COAL       1PP001      A3F
[illegible]   170       008  PERCENTAGE HG IN COAL       1PP001      A3F
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[illegible]    20       008  PERCENTAGE HG IN COAL       1PP001      A3F
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[illegible]   170       008  PERCENTAGE HG IN COAL       1PP001      A3F
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[illegible]   200       008  PERCENTAGE HG IN COAL       1PP001      A3F
[illegible]   130       008  PERCENTAGE HG IN COAL       1PP001      A3F
[illegible]    70       005  PERCENTAGE HG IN COAL       1PP001      A3F
[illegible]    70       005  PERCENTAGE HG IN COAL       1PP001      A3F
[illegible]    70       005  PERCENTAGE HG IN COAL       1PP001      A3F
[illegible]    70       005  PERCENTAGE HG IN COAL       1PP001      A3F
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```
[illegible]   [illegible]   [illegible]   PERCENTAGE MO IN COAL   [illegible]   [illegible]
[illegible]   [illegible]   [illegible]   PERCENTAGE MO IN COAL   [illegible]   [illegible]
[illegible]   [illegible]   [illegible]   PERCENTAGE MO IN COAL   [illegible]   [illegible]
[illegible]   [illegible]   [illegible]   PERCENTAGE MO IN COAL   [illegible]   [illegible]
[illegible]   [illegible]   [illegible]   PERCENTAGE MO IN COAL   [illegible]   [illegible]
[illegible]   [illegible]   [illegible]   PERCENTAGE MO IN COAL   [illegible]   [illegible]
[illegible]   [illegible]   [illegible]   PERCENTAGE MO IN COAL   [illegible]   [illegible]
[illegible]   [illegible]   [illegible]   PERCENTAGE MO IN COAL   [illegible]   [illegible]
[illegible]   [illegible]   [illegible]   PERCENTAGE MO IN COAL   [illegible]   [illegible]
[illegible]   [illegible]   [illegible]   PERCENTAGE MO IN COAL   [illegible]   [illegible]
[illegible]   [illegible]   [illegible]   PERCENTAGE MO IN COAL   [illegible]   [illegible]
[illegible]   [illegible]   [illegible]   PERCENTAGE MO IN COAL   [illegible]   [illegible]
[illegible]   [illegible]   15   PPM MO IN RESIDUAL OIL   [illegible]   [illegible]
[illegible]   [illegible]   15   PPM MO IN RESIDUAL OIL   [illegible]   [illegible]
[illegible]   [illegible]   15   PPM MO IN RESIDUAL OIL   [illegible]   [illegible]
[illegible]   [illegible]   1   NONE   [illegible]   [illegible]
[illegible]   [illegible]   1   NONE   [illegible]   [illegible]
[illegible]   [illegible]   1   NONE   [illegible]   [illegible]
[illegible]   [illegible]   1   NONE   [illegible]   [illegible]
[illegible]   [illegible]   1820   PPM MANGANESE IN COAL   [illegible]   [illegible]
[illegible]   [illegible]   1820   PPM MANGANESE IN COAL   [illegible]   [illegible]
[illegible]   [illegible]   1820   PPM MANGANESE IN COAL   [illegible]   [illegible]
[illegible]   [illegible]   1820   PPM MANGANESE IN COAL   [illegible]   [illegible]
[illegible]   [illegible]   1820   PPM MANGANESE IN COAL   [illegible]   [illegible]
[illegible]   [illegible]   1820   PPM MANGANESE IN COAL   [illegible]   [illegible]
[illegible]   [illegible]   1820   PPM MANGANESE IN COAL   [illegible]   [illegible]
[illegible]   [illegible]   960   PPM MANGANESE IN COAL   [illegible]   [illegible]
[illegible]   [illegible]   960   PPM MANGANESE IN COAL   [illegible]   [illegible]
[illegible]   [illegible]   960   PPM MANGANESE IN COAL   [illegible]   [illegible]
[illegible]   [illegible]   960   PPM MANGANESE IN COAL   [illegible]   [illegible]
[illegible]   [illegible]   960   PPM MANGANESE IN COAL   [illegible]   [illegible]
[illegible]   [illegible]   960   PPM MANGANESE IN COAL   [illegible]   [illegible]
[illegible]   [illegible]   960   PPM MANGANESE IN COAL   [illegible]   [illegible]
[illegible]   [illegible]   960   PPM MANGANESE IN COAL   [illegible]   [illegible]
[illegible]   [illegible]   960   PPM MANGANESE IN COAL   [illegible]   [illegible]
[illegible]   [illegible]   960   PPM MANGANESE IN COAL   [illegible]   [illegible]
[illegible]   [illegible]   960   PPM MANGANESE IN COAL   [illegible]   [illegible]
[illegible]   [illegible]   960   PPM MANGANESE IN COAL   [illegible]   [illegible]
[illegible]   [illegible]   960   PPM MANGANESE IN COAL   [illegible]   [illegible]
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[illegible]   [illegible]   310   PPM MANGANESE IN COAL   [illegible]   [illegible]
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[illegible]   [illegible]   310   PPM MANGANESE IN COAL   [illegible]   [illegible]
[illegible]   [illegible]   310   PPM MANGANESE IN COAL   [illegible]   [illegible]
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[illegible]   [illegible]   310   PPM MANGANESE IN COAL   [illegible]   [illegible]
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[illegible]   [illegible]   310   PPM MANGANESE IN COAL   [illegible]   [illegible]
[illegible]   [illegible]   310   PPM MANGANESE IN COAL   [illegible]   [illegible]
[illegible]   [illegible]   310   PPM MANGANESE IN COAL   [illegible]   [illegible]
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[illegible]   [illegible]   310   PPM MANGANESE IN COAL   [illegible]   [illegible]
[illegible]   [illegible]   310   PPM MANGANESE IN COAL   [illegible]   [illegible]
[illegible]   [illegible]   [illegible]   PPM MANGANESE IN RESIDUAL OIL[illegible]   [illegible]
[illegible]   [illegible]   [illegible]   PPM MANGANESE IN RESIDUAL OIL[illegible]   [illegible]
[illegible]   [illegible]   [illegible]   PPM MANGANESE IN RESIDUAL OIL[illegible]   [illegible]
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[illegible]   [illegible]   [illegible]   PPM OF MN IN DISTILLATE OIL   [illegible]   [illegible]
[illegible]   [illegible]   [illegible]   PPM OF MN IN DISTILLATE OIL   [illegible]   [illegible]
[illegible]   [illegible]   1820   PPM MN IN COAL   [illegible]   [illegible]
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[illegible]   [illegible]   1820   PPM MN IN COAL   [illegible]   [illegible]
[illegible]   [illegible]   1820   PPM MN IN COAL   [illegible]   [illegible]
[illegible]   [illegible]   1820   PPM MN IN COAL   [illegible]   [illegible]
[illegible]   [illegible]   1820   PPM MN IN COAL   [illegible]   [illegible]
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[illegible]  [illegible]   960  PPM MN IN COAL               [illegible]  A3F
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[illegible]  [illegible]   960  PPM MN IN COAL               [illegible]  A3F
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[illegible]  [illegible]      020 PPM MERCURY IN COAL        [illegible]  A3F
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[illegible]  [illegible]  002  PPM MERCURY IN RESIDUAL OIL   F001     A3F
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[illegible]  [illegible]  01   PPM HG IN COAL                F001     A3F
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[illegible]  [illegible]  02   PPM HG IN COAL                F001     A3F
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[illegible]  [illegible]  002  PPM HG IN RESIDUAL OIL          01     A3F
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[illegible]  [illegible]  002  PERCENT HG IN PAINT           F001     A3F
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[illegible]  [illegible]  20   PPM HG IN COAL              1PF001     A3F
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10 20L401A7161   00100   591 PPM TI IN RESIDUAL OIL      100001      A3F
10 20L402A7161   00100   591 PPM TI IN RESIDUAL OIL      100001      A3F
10 20L499A7161   00100   591 PPM TI IN RESIDUAL OIL      100001      A3F
10 10 2011A7171  10    100   PERCENT TIO2 IN EMISSIONS   100001      A3F
10 10L101A7169   00017  130  PPM V IN COAL               100001      A3F
10 10L102A7169   00002  130  PPM V IN COAL               100001      A3F
10 10L103A7169   00017  130  PPM V IN COAL               100001      A3F
10 10L104A7169   00002  130  PPM V IN COAL               100001      A3F
10 10L105A7169   00017  130  PPM V IN COAL               100001      A3F
10 10L106A7169   00002  130  PPM V IN COAL               100001      A3F
10 10L199A7169   00017  130  PPM V IN COAL               100001      A3F
10 10L201A7169   00013  200  PPM V IN COAL               100001      A3F
10 10L202A7169   00017  200  PPM V IN COAL               100001      A3F
10 10L203A7169   00002  200  PPM V IN COAL               100001      A3F
10 10L204A7169   00013  200  PPM V IN COAL               100001      A3F
10 10L205A7169   00005  200  PPM V IN COAL               100001      A3F
10 10L206A7169   00005  200  PPM V IN COAL               100001      A3F
10 10L207A7169   00013  200  PPM V IN COAL               100001      A3F
10 10L208A7169   00017  200  PPM V IN COAL               100001      A3F
10 10L209A7169   00005  200  PPM V IN COAL               100001      A3F
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1U1U0211A2169    000012  280   PPM V  IN COAL                  100001          A3F
1U1U0212A2169    000017  280   PPM V  IN COAL                  100001          A3F
1U1U0299A2169    000160  280   PPM V  IN COAL                  100001          A3F
1U1U0301A2169    000065   90   PPM V  IN COAL                  100001          A3F
1U1U0302A2169    000065   90   PPM V  IN COAL                  100001          A3F
1U1U0303A2169    000065   90   PPM V  IN COAL                  100001          A3F
1U1U0304A2169    000065   90   PPM V  IN COAL                  100001          A3F
1U1U0305A2169    000065   90   PPM V  IN COAL                  100001          A3F
1U1U0306A2169    000065   90   PPM V  IN COAL                  100001          A3F
1U1U0307A2169    000065   90   PPM V  IN COAL                  100001          A3F
1U1U0308A2169    000065   90   PPM V  IN COAL                  100001          A3F
1U1U0309A2169    000065   90   PPM V  IN COAL                  100001          A3F
1U1U0310A2169    000065   90   PPM V  IN COAL                  100001          A3F
1U1U0311A2169    000065   90   PPM V  IN COAL                  100001          A3F
1U1U0312A2169    000065   90   PPM V  IN COAL                  100001          A3F
1U1U0313A2169    000065   90   PPM V  IN COAL                  100001          A3F
1U1U0314A2169    000065   90   PPM V  IN COAL                  100001          A3F
1U1U0315A2169    000065   90   PPM V  IN COAL                  100001          A3F
1U1U0401A2169    0018        5719 PPM V  IN RESIDUAL  OIL      100001          A3F
1U1U0402A2169    0014        5719 PPM V  IN RESIDUAL  OIL      100001          A3F
1U1U0403A2169    0018        5719 PPM V  IN RESIDUAL  OIL      100001          A3F
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1U2U0102A2169    000012  130   PPM V  IN COAL                  100001          A3F
1U2U0103A2169    000017  130   PPM V  IN COAL                  100001          A3F
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1U2U0106A2169    000012  130   PPM V  IN COAL                  100001          A3F
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1U2U0207A2169    000018  280   PPM V  IN COAL                  100001          A3F
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1U2U0299A2169    000018  280   PPM V  IN COAL                  100001          A3F
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1U2U0306A2169    000017   90   PPM V  IN COAL                  100001          A3F
1U2U0307A2169    000017   90   PPM V  IN COAL                  100001          A3F
1U2U0308A2169    000017   90   PPM V  IN COAL                  100001          A3F
1U2U0309A2169    000017   90   PPM V  IN COAL                  100001          A3F
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1U2U0312A2169    000017   90   PPM V  IN COAL                  100001          A3F
1U2U0313A2169    000017   90   PPM V  IN COAL                  100001          A3F
1U2U0314A2169    000017   90   PPM V  IN COAL                  100001          A3F
1U2U0315A2169    000017   90   PPM V  IN COAL                  100001          A3F
1U2U0316A2169    000017   90   PPM V  IN COAL                  100001          A3F
1U2U0401A2169    0018        5719 PPM V  IN RESIDUAL  OIL      100001          A3F
1U2U0402A2169    0018        5719 PPM V  IN RESIDUAL  OIL      100001          A3F
1U2U0403A2169    0018        5719 PPM V  IN RESIDUAL  OIL      100001          A3F
1U1U0101A2167    000018  130   PPM ZN IN COAL                  100001          A3F
1U1U0102A2167    000018  130   PPM ZN IN COAL                  100001          A3F
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[illegible]  [illegible]  120   PPM ZN IN COAL          [illegible]  [illegible]
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10206309A2167   00048   120   PPM ZN IN COAL              100001      A3F
10206310A2167   00048   120   PPM ZN IN COAL              100001      A3F
10206311A2167   00048   120   PPM ZN IN COAL              100001      A3F
10206312A2167   00048   120   PPM ZN IN COAL              100001      A3F
10206313A2167   00048   120   PPM ZN IN COAL              100001      A3F
10206314A2167   00048   120   PPM ZN IN COAL              100001      A3F
10206315A2167   00048   120   PPM ZN IN COAL              100001      A3F
10206316A2167   00048   120   PPM ZN IN COAL              1000 1      A3F
10204001A2167   0048      019 PPM ZN IN RESIDUAL OIL      1000 1      A3F
10204002A2167   0048      019 PPM ZN IN RESIDUAL OIL      1000 1      A3F
10204003A2167   0048      019 PPM ZN IN RESIDUAL OIL      1000 1      A3F
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SCC EMISSION FACTOR ORIGIN

Field Identification POLLUTANT: Lead - Pb

1-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80

SCC (or AEI)	Date (mo/yr)	Pollutant Code	Reliability Code	Source Origin Code / Comments	Card No.
[illegible]	11/76	[illegible]	D	C REF 55	1
[illegible]			B	D REF 9 CALCULATED FROM AN 85% CONTROL EFFICIENCY	1
[illegible]			D	C REF 55	1
[illegible]			D	C REF 55	1
[illegible]			D	C REF 55	1
[illegible]			D	C REF 55	1
[illegible]			D	C REF 55	1
[illegible]			D	C REF 55	1
[illegible]			D	C REF 55 THE BLAST FURNACE LEAD EMISSION FACTOR OF	1
[illegible]				0.124 WAS APPORTIONED BETWEEN 30300801 AND 30300802	2
[illegible]				BASED ON PARTICULATE REDC BLAST FURNACE EMISSION FCTRS	3
[illegible]			B	C REF 55 THE BLAST FURNACE LEAD EMISSION FACTOR OF	1
[illegible]				0.124 WAS APPORTIONED BETWEEN 30300801 AND 30300802	2
[illegible]				BASED ON PARTICULATE REDC BLAST FURNACE EMISSION FCTRS	3
[illegible]			D	C REF 55	1
[illegible]			B	B REF 23 RANGE 0.07 TO 0.4	1
[illegible]			B	B REF 23 RANGE 0.1 TO 0.3	1
[illegible]			B	B REF 55	1
[illegible]	▼	▼	D	B REF 55	1

SCC EMISSION FACTOR ORIGIN

Field Identification POLLUTANT: LEAD - Pb

SCC (or AEC)	Units (mass/unit)	Pollutant Code	Source Origin Code	Reliability Code	Comments	Card No.
[illegible]	[illegible]	[illegible]	D	C	REF 85	
[illegible]			D	B	REF 85 UNITS CONVERSION MADE FROM PRODUCED TO CHARGE	
[illegible]			D	B	REF 85 UNITS CONVERSION MADE FROM PRODUCED TO CHARGE	
[illegible]			[illegible]	C	REF 85 UNITS CONVERSION MADE FROM PRODUCED TO CHARGE	
[illegible]			D	C	REF 66, 70.	
[illegible]			D	C	REF 70 UNITS CONVERSION MADE FROM PRODUCT TO CHARGE	
[illegible]			D	C	REF 85 UNITS CONVERSION MADE FROM PRODUCT TO CHARGE	
[illegible]			D	C	REF 85 UNITS CONVERSION MADE FROM PRODUCT TO CHARGE	
[illegible]			D	C	REF 85 UNITS CONVERSION MADE FROM PRODUCT TO CHARGE	
[illegible]			D	C	REF 23	
[illegible]			D	C	REF 85 UNITS CONVERSION MADE FROM PRODUCT TO CHARGE	
[illegible]			D	C	REF 85 UNITS CONVERSION MADE FROM PRODUCT TO CHARGE	
[illegible]			D	C	REF 85 UNITS CONVERSION MADE FROM PRODUCT TO CHARGE	
[illegible]			D	D	REF 85 UNITS CONVERSION MADE FROM PRODUCT TO CHARGE	
[illegible]			D	C	REF 23 UNITS CONVERSION MADE FROM PRODUCT TO CHARGE	
[illegible]			D	B	REF 23 UNITS CONVERSION MADE FROM BATTERIES TO TONS	
[illegible]			D	B	REF 23 UNITS CONVERSION MADE FROM BATTERIES TO TONS	
[illegible]			D	B	REF 23 UNITS CONVERSION MADE FROM BATTERIES TO TONS	
[illegible]			D	B	REF 23	

B. Area Source Data

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01RESIDENTIAL ANTHRACITE COAL
02RESIDENTIAL BITUMINOUS COAL
03RESIDENTIAL DISTILLATE OIL
04RESIDENTIAL RESIDUAL OIL
05RESIDENTIAL NATURAL GAS
06RESIDENTIAL WOOD
07COMM-INST ANTHRACITE COAL
08COMM-INST BITUMINOUS COAL
09COMM-INST DISTILLATE OIL
10COMM-INST RESIDUAL OIL
11COMM-INST NATURAL GAS
12COMM-INST WOOD
13INDUSTRIAL ANTHRACITE COAL
14INDUSTRIAL BITUMINOUS COAL
15INDUSTRIAL COKE
16INDUSTRIAL DISTILLATE OIL
17INDUSTRIAL RESIDUAL OIL
18INDUSTRIAL NATURAL GAS
19INDUSTRIAL WOOD
20INDUSTRIAL PROCESS GAS
21RESIDENTIAL ON-SITE INCINERATION
22INDUSTRIAL ON-SITE INCINERATION
23COMM-INST ON-SITE INCINERATION
24RESIDENTIAL OPEN BURNING
25INDUSTRIAL OPEN BURNING
26COMM-INST OPEN BURNING
43OFF HIGHWAY GASOLINE VEHICLES
44OFF HIGHWAY DIESEL VEHICLES
45RAILROAD LOCOMOTIVES
46MILITARY AIRCRAFT LTO'S
47CIVIL AIRCRAFT LTO'S
48COMMERCIAL AIRCRAFT LTO'S
49COAL VESSELS
50DIESEL OIL VESSELS
51RESIDUAL OIL VESSELS
52GASOLINE VESSELS
53SOLVENT PURCHASED
54GASOLINE MARKETED
55UNPAVED ROAD TRAVEL
56UNPAVED AIR STRIP LTO'S
57CONSTRUCTION
58MISCELLANEOUS WIND EROSION
59LAND TILLING
60FOREST WILD FIRES
61MANAGED BURNING (SLASH/PRESCRIBED BURNING)
62AGRICULTURAL FIELD BURNING
63FROST CONTROL (ORCHARD HEATERS)
64STRUCTURAL FIRES
65LIGHT DUTY GASOLINE FUEL
66HEAVY DUTY GASOLINE FUEL
67HEAVY DUTY DIESEL FUEL
01TONS
02TONS
03THOUSAND GALLONS
04THOUSAND GALLONS
05MILLION CUBIC FEET
06TONS
07TONS
08TONS
09THOUSAND GALLONS
10THOUSAND GALLONS
11MILLION CUBIC FEET
12TONS
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13 TONS                                                                              A [illegible]
14 TONS                                                                              A [illegible]
15 TONS                                                                              A [illegible]
16 THOUSAND GALLONS                                                                  A [illegible]
17 THOUSAND GALLONS                                                                  A [illegible]
18 MILLION CUBIC FEET                                                                A [illegible]
19 TONS                                                                              A [illegible]
20 MILLION CUBIC FEET                                                                A [illegible]
21 TONS                                                                              A [illegible]
22 TONS                                                                              A [illegible]
23 TONS                                                                              A [illegible]
24 TONS                                                                              A [illegible]
25 TONS                                                                              A [illegible]
26 TONS                                                                              A [illegible]
43 THOUSAND GALLONS                                                                  A [illegible]
44 THOUSAND GALLONS                                                                  A [illegible]
45 THOUSAND GALLONS                                                                  A [illegible]
46 LANDING/TAKE OFF CYCLES                                                           A [illegible]
47 LANDING/TAKE OFF CYCLES                                                           A [illegible]
48 LANDING/TAKE OFF CYCLES                                                           A [illegible]
49 TONS                                                                              A [illegible]
50 THOUSAND GALLONS                                                                  A [illegible]
51 THOUSAND GALLONS                                                                  A [illegible]
52 THOUSAND GALLONS                                                                  A [illegible]
53 TONS                                                                              A [illegible]
54 THOUSAND GALLONS                                                                  A [illegible]
55 THOUSAND VEHICLE MILES                                                            A [illegible]
56 LANDING/TAKE OFF CYCLES                                                           A [illegible]
57 ACRES                                                                             A [illegible]
58 ACRES                                                                             A [illegible]
59 ACRES                                                                             A [illegible]
60 ACRES                                     TONS PER ACRE                           A [illegible]
61 ACRES                                     TONS PER ACRE                           A [illegible]
62 ACRES                                     TONS PER ACRE                           A [illegible]
63 NUMBER OF ORCHARD HEATERS                 NUMBER OF DAYS FIRED PER YEAR           A [illegible]
64 NUMBER OF STRUCTURAL FIRES PER YEAR                                               A [illegible]
 [illegible] THOUSAND GALLONS                                                        A [illegible]
 [illegible] THOUSAND GALLONS                                                        A [illegible]
 [illegible] THOUSAND GALLONS                                                        A [illegible]
01 A2 10 7     000001  1.00   PPM IN COAL                                            A [illegible]
01 A2 10 7     000001  5.00   PPM IN COAL                                            A [illegible]
01 A2 10 5     000001   .00   PPM IN COAL                                            A [illegible]
01 A2 11 0     000001  10.0   PPM IN COAL                                            A [illegible]
01 A2 21 5   2.00      10.5   PERCENTAGE IN COAL                                     A [illegible]
01 A2 11 2     000001 12.00   PPM IN COAL                                            A [illegible]
01 A2 11 9     000001  7.00   PPM IN COAL                                            A [illegible]
01 A2 10 2     00002  11.00   PPM IN COAL                                            A [illegible]
01 A2 12 8     000001   .00   PPM IN COAL                                            A [illegible]
01 A2 14 0     000001 60.00   PPM IN COAL                                            A [illegible]
01 A2 11 2     000001 18.00   PPM IN COAL                                            A [illegible]
01 A2 19 2     00018    .00   PPM IN COAL                                            A [illegible]
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[illegible]   PERCENT BARIUM IN REFUSE
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[illegible]   PPM SILVER IN REFUSE
[illegible]   PPM MOLYBDENUM IN REFUSE
[illegible]   PPM SELENIUM IN REFUSE
[illegible]   PPM ARSENIC IN REFUSE
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[illegible]   PERCENT CHLORINE IN REFUSE
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[illegible]   PPM BORON IN REFUSE
[illegible]   PPM BERYLLIUM IN REFUSE
[illegible]   PERCENT LEAD IN REFUSE
[illegible]   PERCENT BARIUM IN REFUSE
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22AE110     UG2    29    PPM CADMIUM IN REFUSE                         AB
22AE106     UG2     .8   PPM SILVER IN REFUSE                          AB
22AE139     UG2    45    PPM MOLYBDENUM IN REFUSE                      AB
22AE159     UG2     .8   PPM SELENIUM IN REFUSE                        AB
22AE103     UG2    22    PPM ARSENIC IN REFUSE                         AB
22AE167   Z0000      5.65PERCENT ZINC IN REFUSE                        AB
22AE119   Z0000      2.07PERCENT COPPER IN REFUSE                      AB
22AE136     UG2   827    PPM NICKEL IN REFUSE                          AB
22AE132     UG2   771    PPM MANGANESE IN REFUSE                       AB
22AE112   Z0000      1.90PERCENT CHROMIUM IN REFUSE                    AB
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22AE215   Z0000      2.23PERCENT CHLORINE IN REFUSE                    AB
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22AE108     UG2     277  PPM BORON IN REFUSE                           AB
22AE105     UG2      2.6 PPM BERYLLIUM IN REFUSE                       AB
23AE128   Z0000      2.17PERCENT LEAD IN REFUSE                        AB
23AE107   Z0000      1.07PERCENT BARIUM IN REFUSE                      AB
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23AE156     UG2     .8   PPM SILVER IN REFUSE                          AB
23AE139     UG2    45    PPM MOLYBDENUM IN REFUSE                      AB
23AE159     UG2     .8   PPM SELENIUM IN REFUSE                        AB
23AE103     UG2    22    PPM ARSENIC IN REFUSE                         AB
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23AE119   Z0000      2.07PERCENT COPPER IN REFUSE                      AB
23AE136     UG2   827    PPM NICKEL IN REFUSE                          AB
23AE132     UG2   771    PPM MANGANESE IN REFUSE                       AB
23AE112   Z0000      1.90PERCENT CHROMIUM IN REFUSE                    AB
23AE164     UG2    35    PPM VANADIUM IN REFUSE                        AB
23AE215   Z0000      2.23PERCENT CHLORINE IN REFUSE                    AB
23AE202     UG2   987    PPM FLUORIDE IN REFUSE                        AB
23AE108     UG2     277  PPM BORON IN REFUSE                           AB
23AE105     UG2      2.6 PPM BERYLLIUM IN REFUSE                       AB
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55AE140     UU81  18U    PPM IN DUST                                   AB
55AE132     UU81   1.63  PPM IN DUST                                   AB
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55AE161     UU81     6   PPM IN DUST                                   AB
55AE159     UU81    18   PPM IN DUST                                   AB
55AE167     UU81     5   PPM IN DUST                                   AB
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56AE119     UU0U2    9   PPM IN DUST                                   AB
56AE202     UU0U2    2   PPM IN DUST                                   AB
56AE128     UU0U2    4   PPM IN DUST                                   AB
56AE140     UU0U218U     PPM IN DUST                                   AB
56AE132     UU0U2 1.63   PPM IN DUST                                   AB
56AE136     UU0U2    8   PPM IN DUST                                   AB
56AE161     UU0U2    6   PPM IN DUST                                   AB
56AE159     UU0U2   18   PPM IN DUST                                   AB
56AE167     UU0U2    5   PPM IN DUST                                   AB
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59AE140     UU0U318U     PPM IN DUST                                   AB
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[illegible]   [illegible]   [illegible]   NONE                                A [illegible]
[illegible]   [illegible]   [illegible]   GRAMS PER GALLON OF GASOLINE        A [illegible]
[illegible]   [illegible]   [illegible]   GRAMS PER GALLON OF GASOLINE        A [illegible]
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G. "Free" Area Source Data

```
ADRUBBER TIRE WEAR                                                  A1F
AEBRAKE LINING WEAR                                                 A1F
AFMOTOR OIL CONSUMPTION                                             A1F
ADMILLION VEHICLE MILES TRAVELLED                                   A2F
AEMILLION VEHICLE MILES TRAVELLED                                   A2F
AFMILLION VEHICLE MILES TRAVELLED                                   A2F
ADA2107    11         1    NONE                                     A3F
ADA2110    01         1    NONE                                     A3F
ADA2167   16          1    NONE                                     A3F
AEA2001    05         1    NONE                                     A3F
AFA2110    1002       1    NONE                                     A3F
AD         12/76 A2107 H E: REF 3
AD         12/76 A2110 H E: REF 6
AD         12/76 A2167 H E: REF 20
AE         12/76 A2001 A E: REF 22
AF         12/76 A2110 A E: REF 22
```

EMISSION FACTOR ORIGIN

Field Identification — POLLUTANT: Arsenic, Barium, Chromium, Zinc

1-10	11-20		21-30			31-40	41-50	51-60	61-70	71-80
SCC (or ASC)	Date (mo/yr)	Pollutant Code	Reliability Code	Source Origin Code	Comments					Card No.
AC	12/72	[illegible]	B	E	REF 3					
AD			B	B	REF 4					
AD			B	E	REF 20					
AE			A	E	REF 22					
AF			A	B	REF 22					

"FEE" AREA SOURCE INPUT

State	County	AQCR	ASC	Pollutant Code		Source Rate	Source Activity Factor	Emissions (T/Year)	Comments	ACTION
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	[illegible]	[illegible]				.157				
	[illegible]	[illegible]				96				
	[illegible]	[illegible]				.177				
	[illegible]	[illegible]				82				
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	[illegible]	[illegible]				92				
▼	[illegible]	[illegible]	▼	▼	▼	393				

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APPENDIX B

LEAD SPECIAL REPORT

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10. LEAD

MINING AND MILLING[1,2]

About 85 percent of the domestic supply of lead recovered from primary lead ores comes from Missouri.[1,2] The predominant ore mined in Missouri is galena (lead sulfide, PbS, 86.6 percent lead), having an average lead content of about 4.8 percent. The other three major states that produce lead are Idaho, Utah, and Colorado. The average lead content of these ores are 4.7, 8, and 3 percent, respectively. Minor amounts of lead come from Nevada, Arizona, New Mexico, and California.[2] Lead is also associated with recovery of copper and zinc ores.

After it is mined, the ore is transported to concentrating plants, where it is concentrated before shipment to the smelter. Concentration is accomplished by crushing, screening, classification (rod mill and ball mill), and flotation (cleaning, thickening, and filtering).

Lead emissions are a result of ore handling, crushing, and screening, and of wind loss from the outdoor storage of concentrates. At present, cyclones and baghouses are the principal air pollution control equipment used in the milling operations. The chemical composition of these emissions is the same as that of the ore itself because all processes preceding smelting involve physical rather than chemical operations (e.g., the principal emission of lead from the mining and milling of galena is lead sulfide, PbS). The controlled emission factor for the mining and milling of lead ores is presented in Table 10-1.[1] Lead emissions from the mining and milling of copper ores are negligible.[2]

PRIMARY METALLURGICAL INDUSTRIES

Primary Lead Smelting[1,3]

Primary lead production involves the upgrading of ore by a flotation-concentration process, sintering of the concentrated ore, processing of the sintered material in a blast furnace, and refining to produce lead bullion.[1,3] Sintering converts lead sulfides to lead oxides, and lead oxides are reduced with coke in a blast furnace to produce lead bullion. The final step, refining, removes the last impurities from the bullion.

Gases produced by sintering are usually cleaned. In 1970 the gas, dust, and fume emissions from blast furnaces were controlled by baghouses at all lead smelters. Refining emissions were also controlled by baghouses at most plants.[1]

The entire smelting process is summarized in Figure 10-1. Emissions from the stacks are principally lead oxides. The particle size of lead emissions from baghouses was reported to be 1 micron or less, while those from concentrate storage ranged upward to 100 microns.[1] Lead emission factors for the primary lead smelting industry are presented in Table 10-1.

Primary Copper Smelting[1,2,4-6]

Copper smelting generally consists of roasting, reduction in a reverberatory furnace, converting, and refining (Figure 10-2). Because lead sulfide is often found in copper ore, lead emissions are to be expected.

Roasting removes volatile impurities and oxidizes sulfur. The "roasted" product is then fed to the reverberatory furnace which reduces copper and iron. This molten matter is then processed through a converter which removes the iron; and finally, the copper is refined to the desired purity.

The processes most likely to emit the majority of the lead are the roaster, the reverberatory furnace, and the converter. The probable chemical form of the lead emissions is lead oxide. Based on particulate samples collected before and after an electrostatic precipitator (ESP) using EPA Method 5 and lead analysis by atomic absorption, the collection efficiency of an ESP on lead emissions from a converter has been reported to be about 90 percent.[4,5] Lead emissions for these processes are dependent on the lead content of the copper ore.

Emission factors (uncontrolled and controlled) shown in Table 10-1 for the converter are based on the percent lead found in the particulate samples collected and the particulate emission factor for converters.[4-6] The controlled emission factor reported for combined emissions from a roaster and reverberatory furnace is based on percent lead found in collected particulate matter exiting from an ESP and the particulate emission factor.[4,5]

Primary Zinc Smelting[6]

Lead minerals are also found in zinc ore. The zinc smelting process is similar to copper smelting. Roasting removes sulfur, and sintering or nodulizing agglomerates the ore for reduction in a furnace or by an electrolytic process. With the exception of the electrolytic reduction process, lead is emitted during all phases of zinc smelting. Condensers, cyclones, baghouses and/or electrostatic precipitators are used to control emissions. Lead emission factors are specified in Table 10-1 for sintering, vertical retort, and horizontal retort.

SECONDARY METALLURGICAL RECOVERY AND OTHER INDUSTRIAL SOURCES

Secondary Lead Smelting[1,6-8]

Secondary lead recovery plant operations usually include lead scrap receiving yards, battery cutting areas, oxidizing furnaces, refining kettles (pot furnaces), casting lines, and the shipping of lead ingots. As Figure 10-3 shows, the materials are processed into hard lead.

Lead emissions and control equipment are similar to those associated with primary ore handling. Lead emissions result from the operation of both types of oxidizing furnaces (reverberatory and blast furnaces). Lead emissions from the refining kettles will occur, but are lower than the oxidizing furnaces because of the difference in operating temperatures. Scrubbers and baghouses are used for the furnaces and refining kettles. Emission factors are presented in Table 10-2.

Steel Production[1,5,6,9-12]

Trace amounts of lead are found in the feed materials (iron ore, coal, and scrap metal) for the major steel making operations. Sources of lead emissions include sintering and the four main furnace operations employed in the production of steel: (a) blast furnace; (b) open-hearth furnace; (c) basic oxygen furnace; and (d) electric arc furnace.

Sintering is a major source of particulates in the steelmaking process. A typical lead content of these particulates is 320 ppm.[6] Major emission points are the discharge end and the windbox. An uncontrolled sinter emission factor is presented in Table 10-2.

Large quantities of particulate are produced during the operation of the blast furnace. Reference 9 reports lead in particulate samples collected at steel mills varying from 100 to 10,000 parts per million; however, the emission sources were not specified. An emission factor for lead emissions from a blast furnace is presented in Table 10-2.

In the open-hearth furnace, steel is made from a mixture of scrap and pig iron in a shallow basin or hearth. Lead is emitted during all operations. For an uncontrolled open-hearth furnace, the particulate emission factors are 4.15 (no oxygen lance) and 8.7 (oxygen lance) kilograms per 1,000 kilograms of steel produced.[5] Dust samples from an open-hearth furnace were analyzed with a reported average lead content of about 0.8 percent.[1] Particulate matter collected from an open-hearth furnace was also analyzed by spectrographic techniques, and the lead content was about 3 percent.[9] Reference 11 reports the lead content of particulate from an open-hearth furnace controlled by electrostatic precipitator as about 1 percent. Based on the lead content and the particulate emission factors given above, the emission factors for lead were estimated for an open-hearth furnace (Table 10-2).

The basic oxygen furnace consists of a refractory-lined pear-shaped vessel mounted on trunions. Oxygen is added to the molten mass within the furnace to mix the mass--increasing the lead (oxide) emissions. Scrubbers, electrostatic precipitators, or a combination of control equipment are sometimes employed to reduce particulate emissions. The uncontrolled particulate emission factor for this source is 25.5 kilograms per 1,000 kilograms of steel produced (based on particulate sampling).[5] The average lead content of the particulates collected from several basic oxygen furnaces was about 0.4 percent.[6] The emission factor for lead (Table 10-2) is based on the uncontrolled particulate emission factor and the percent lead found in the collected particulate material.

The electric arc furnace is a refractory-lined vessel with carbon electrodes passing through the top of the furnace. This type of operation produces fewer particulates than do the other processes. The particulate emission factors (uncontrolled) are 5.5 (oxygen lance) and 4.6 (no oxygen lance) kilograms per 1,000 kilograms of steel produced.[5] Based on analysis of particulate samples collected from several electric arc furnaces, the lead content ranged from 0.17 to 5.7 percent with an average of 2.0 percent.[6] The emission factors for lead are based on the particulate emission factors and average percent lead found in the particulate samples.

In Reference 12, an EPA particulate sampling train equipped with a cascade impactor was used to collect particulate before and after a baghouse controlling emissions from an electric arc furnace. Processes included meltdown, oxidizing, slagging, and refining steps. The lead collection efficiency of the baghouse was about 99.8 percent. The emission factors shown in Table 10-2 are based on the percent lead found in the particulate samples and the process weight rate obtained during the testing.

Gray Iron Foundry[1,5,6,9]

There are three types of furnaces used in the gray iron industry: (a) cupola, the most common; (b) electric arc furnace; and (c) reverberatory furnace. In the cupola furnace operation charging fuel, fluxing material (e.g., limestone) and scrap iron, are melted together. The molten mass is used to make metal castings or specialty iron products.

The amount of lead emissions (as lead oxide) resulting from the operation of the cupola is determined primarily by the type and quality of the scrap, fuel, and furnace size. Particulate samples were collected from a baghouse servicing a cupola furnace and analyzed for lead by spectrographic methods. The average lead content was reported to be 17 percent.[9]

Air pollution control equipment for cupolas consists of high efficiency cyclones; dynamic water scrubbers, venturi scrubbers, impingement wet scrubbers, baghouses, and electrostatic precipitators, or a combination thereof.

Afterburners are also employed but mainly for control, by oxidation, of carbon monoxide emissions.[9]

Reference 1 reports that dust samples collected in the foundry area showed a lead range of 0.5 to 2.0 percent (based on spectrographic analysis) with an average lead content of about 1.2 percent. Lead emission factors for cupola, electric arc and reverberatory furnaces are given in Table 10-2.[1,5,6,9]

Brass and Bronze[1,5,6,9,13,14]

Lead content in various red and yellow brasses usually ranges from less than 1 to 8 percent with a high value of 25 percent.[1,9] There are several furnace (oil and gas-fired) types employed in the production of brass and bronze alloys. Slabs and billets (brass and bronze shapes) are formed in reverberatory furnaces. Commercial castings are products from induction, crucible, rotary, and electric furnaces.

Baghouses are the most efficient air pollution control equipment in this industry. Based on stack tests, the collection efficiency has been reported to be approximately 95 percent. Electrostatic precipitators have not been satisfactory in controlling zinc and lead oxide fumes. Lead oxide, in particular, has been difficult because of its high resistivity. Scrubbers have also been ineffective in controlling emissions in the less than 1 micrometer size range.[9]

Particulate sampling using EPA Method 5 has been conducted on three plants, with lead analyses by atomic absorption.[13,14] These furnaces (types not specified) were fired by natural gas and controlled by baghouses. Particulate emissions ranged from 0.004 to 2.931 pounds per hour with an average value of 1.36 pounds per hour. Lead emissions (based on atomic absorption in the particulate samples) ranged from 0.86 to 12.4 percent with an average value of 6.1 percent. No process weight data were provided from which to develop emission factors from the tests. The emission factors presented in Table 10-2 are based on percent lead found in the EPA stack tests, data reported in Reference 9 and the particulate emission factors.[5,6,9,13,14]

Ferroalloys[1,2,5,6,15,16]

The ferroalloy industry uses three types of furnaces to prepare molten metal for casting: (a) electric arc; (b) aluminothermic; and (c) blast furnace. Most widely used is the electric furnace in which carbon electrodes cause reduction of metallic oxides. In the aluminothermic furnace, the metallic oxides are reduced by aluminum. The blast furnace is infrequently used to reduce the raw ore. Other ferroalloy operations are slag processing (concentrating or shotting), casting, sizing, and shipping of finished ferroalloy.

Control measures used in the ferroalloy industry include process changes, improving raw material sizing and quality, and the application of high energy scrubbers, baghouses and concomitant cooling systems, and wet electrostatic precipitators. Lead emissions from the furnaces are in the lead oxide form.[1,2,15]

X-ray diffraction analyses of dust fumes from a silicomanganese (SiMn) and manganese ore-lime melt electric furnace showed lead oxide contents of 0.47 and 0.98 percent, respectively.[2] No particulate emission factor appears in the literature for the manganese ore-lime melt furnace. The particulate emission factor for the SiMn electric furnace is 97.5 kilograms per 1,000 kilograms of SiMn produced.[5] Based on this emission factor and the percent lead reported from Reference 2, the emission factor for lead is shown in Table 10-2.

A silicon metal electric furnace was tested by EPA.[16] Particulate samples were collected by EPA Method 5 before and after the exhaust gases through a baghouse. The particulate samples were analysed for elements by optical emission spectrographic and visual absorption spectrophotometric techniques. The inlet and outlet lead contents were 0.00026 and 0.000065 percent, respectively. Process weight data were not given. The emission factors shown in Table 10-2 are based on the percent lead found in the particulate samples and the uncontrolled particulate emission factor (312.5 kilograms per 1,000 kilograms of silicon metal).[5]

The average lead content of particulate from ferromanganese electric and blast furnaces is about 0.9 percent.[1] The particulate emission factors for the electric and blast furnaces are 22.5[5] and 205[1] kilograms per 1,000 kilograms of ferromanganese produced, respectively. The emission factors for lead shown in Table 10-2 are based on the above data.

Cement Plant

Lead is present in most of the basic materials used to produce cement. In the dry process, limestone is crushed, ground, and ball milled. With the exception of a slurry produced initially in the raw mill, the wet process is the same as the dry process.

Dry Process[6,17]

Two plants using the dry processing method were visited, and particulate samples were obtained by EPA Method 5.[17] Sources tested included the kiln, raw mill, raw mill separator, feeding to raw mill, and finishing mill. All sources were controlled by individual multicyclones and/or baghouses. Samples were taken from the baghouse effluent. Some of the samples (total catch) were analysed by emission spectroscopy for trace metals. The emission factors (Table 10-2) were calculated from the percent of lead present in the sample and the emission factor calculated for total particulates emitted from the sources.

Wet Process[6,18]

Particulate emissions were obtained by EPA Method 5 at three wet process cement plants.[18] Sources tested included the kilns, clinker coolers, and finishing mill. The kilns were controlled by electrostatic precipitators or baghouses, and the finishing mill was controlled by a baghouse. Samples were obtained at the various control device outlets and analysed for trace metals by emission spectrography and optical emission spectrography. Emission factors (Table 10-2) were calculated as described above for the dry process.

PROCESSING AND UTILIZING LEAD AND ITS COMPOUNDS

Lead Oxide[1,6,19]

There are three main lead oxides produced: (a) lead monoxide or litharge (PbO); (b) lead dioxide (PbO_2); and (c) trilead tetraoxide or red lead (Pb_3O_4). Lead monoxide is used mainly in the production of storage batteries and pigments. Lead dioxide is employed in the production of dyes, chemicals, matches, pyrotechnics, rubber substitutes, and as a curing agent in polysulfide polymers. Trilead tetraoxide is produced from litharge and is used in pigment production.

Figure 10-4 illustrates a generalized lead oxide production process using both the Barton Pot and calcining furnace. The processes tested at one plant were the Barton Pot, and inlet-outlet of the cyclone and baghouse controlling the calcining furnace.[19] Particulate samples were collected by EPA Method 5, and analysed for lead by atomic absorption. The control system for the hammermill and calcining, consisting of a cyclone followed by a baghouse, had a lead removal efficiency of 99.97 based on the total catch of the EPA train. The emission factors developed are shown in Table 10-3.

Storage Batteries[6,20]

Wet and dry storage batteries are produced from lead pigs and lead monoxide. Lead emissions result from the casting, smelting, pasting, stacking, and burning steps used in producing the batteries. Almost all sources of lead are controlled by cyclones, water sprays, and a baghouse (often in series).

One plant producing lead batteries has been tested using EPA Method 5 to determine emissions from the casting furnace, paste mixer, plate stacking, element burning, and battery assembly.[20] The samples were analysed for lead by flame atomic absorption. The emission factors (Table 10-3) are based on the EPA train total catch, process weight rates, and the amount of lead found by atomic absorption in the particulate matter. The emission factors developed from Reference 6 are also shown in Table 10-3 for comparison. A schematic of a typical lead battery manufacturing process is shown in Figure 10-5.

In the aforementioned plant the paste mixer off gas was controlled by a scrubber with a lead collection efficiency of about 84.9 percent. The stacking, burning and battery assembly operations were controlled by a baghouse which resulted in a lead removal efficiency from the particulate matter of about 96.7 percent (based on EPA train total catch).[20]

Gasoline Additives[9]

There are two basic antiknock agents produced at gasoline additive plants: tetraethyl lead (TEL) and tetramethyl lead (TML). These two compounds are mixed with chloride-bromide additives after the sodium-lead or the electrolytic process.

In the sodium-lead process, lead particulate emissions, probably lead oxide, result from the lead melter, sodium-lead alloy pot, and lead recovery furnace. Lead is emitted as vapor in the form of TML and TEL from the autoclaves, steam distillation, purification, and possibly, the blending process. The released TML and TEL are quickly reduced in the atmosphere, with lead oxide formed as one of the products. Particulate emissions are controlled by high-energy venturi scrubbers, and cyclones with water sprays. Vapors are controlled by condensing and refrigeration systems. See Figure 10-6 for the schematic of the process.

Lead emissions from the electrolytic process are in the vapor form (TML and TEL). The emissions result from the stripping, distilling, solvent extraction and possibly the blending steps. Vapor emissions are controlled by condensing and refrigeration systems (Figure 10-7).

Emission factors for the production of gasoline additives from the sodium-lead alloy and electrolytic processes are shown in Table 10-3.

Cable Covering[1,6,21]

Lead sheaths are used to cover the outer layer of telephone lines, telegraph lines, and underground cables for electrical power distribution. Three types of presses are used to cover cable: (a) vertical hydraulic press; (b) straight-through press; and (c) continuous extrusion press.

Cyclones and bag filters are employed on the melt pots, presses, and possibly on the stripping machine. Lead emissions have been reported to be in the form of elemental lead, lead oxides, and silicates.[1,21] Based on questionnaire data, the particle size of the controlled emissions from a cable-covering plant ranges from 0.015 to 5 micrometers.[1]

One cable-covering plant tested by EPA uses continuous extrusion presses.[21] Three stacks were tested using EPA Method 5. The following processes were serviced by the stacks: (a) Stack 1--dross kettle, Robertson electric lead melt pot, Robertson press, and Perrille press; (b) Stack 2--Perrille gas-fired lead melt pot; and (c) Stack 3--Perrille press lead pit. The particulate matter collected from each stack was analysed for lead by flameless atomic adsorption. The emission factors shown in Table 10-3 are based on the lead content of particulate and the amount of lead processed during testing. The dross kettle did not operate during one test, and its operation increased lead emissions by a factor of 15.

Lead Pigments[1,4,6]

Pigment and paint production represents a major source of lead and lead compounds. Lead pigments include red lead (the major pigment), white lead, lead chromates, and leaded zinc oxides. Regardless of the type of pigment produced or process employed, operations in common are grinding or pulverising, bagging, and material handling. No chemical reactions occur in any of these processes.

Limited data are available for lead emission factors for the production of lead pigments. The following source test data provided by the pigment industry are reported in Reference 4:

Process	Type of control	Percent lead in Particulate	Number of tests
Blenders-baggers	None	29	2
Dumping-bin	None	19	3
Grinders and hoppers	None	23 to 31	4
Air dryer	Baghouse	60 to 62	2
Mechanical dryer	None	58 to 61	2
Grinders	Baghouse	58	1
Lead kettle	None	≈ 100	2
Drum distributor and bagger	None	60 to 61	2

However, supporting data are not given for: (a) lead pigment produced; (b) sampling and analysis methods used; and (c) process weight rates. Table 10-3 contains emission factors for the production of various lead pigments.

Paint[1,5]

Lead pigment is added to an oil or resin and an organic solvent to produce paints. The emissions of lead primarily result from the dry pigment weighing, mixing, and grinding operations. Tinting, thinning, and packaging operations also occur in the manufacture of lead based paints. No chemical reactions take place.

Air pollution control equipment (if used) consists of baghouses and wet scrubbers. Particulate matter emitted from pigment handling is about 0.5 to 1 percent of the pigment. An emission factor for paint manufacture is presented in Table 10-3.

Lead Solder[1,4,6]

Lead solders are available in wire, tape, bar, or pellet form and contain about 40 to 98 percent lead by weight. Cyclones are used to control lead oxide emissions from liquid solder.[1,4]

Emission factors for a lead solder melt pot used for seam soldering are reported in Table 10-3. The emission factors are based on measurements of the amount of lead emitted in the particulate matter (EPA Method 5) and the amount of solder melted.[4] Some of the particulate samples were analysed for lead by atomic absorption. Emission factors presented may not be based on the correct process weight rate. Also given in Table 10-3 is an emission factor for all can manufacturing operations based on questionnaires from industrial sources.[6]

Type Metal[6]

Type metal alloys contain lead, antimony and tin. Production of these metals begins with the recovery of lead from batteries, lead pipe, etc., in a reverberatory blast and/or pot furnace. Antimony and tin are added and the mixture is cast. Lead oxide emissions result from the melting furnaces and the casting operations. Emission factors are presented in Table 10-3.

Metallic Lead[1,6]

Lead is used in the production of terne metal, weights and ballasts, plumbing supplies, caulking lead, roofing materials, casting metal, foil, sheet lead, galvanizing, annealing, and lead plating. The general process steps involved in the production of metallic lead products are melting, casting, and mechanical forming by extrusion or rolling.

Lead emissions as lead oxide result from the melting and casting processes. Air pollution control equipment is usually not employed except for product recovery. The uncontrolled emission factor in Table 10-3 is based on questionnaires from manufacturers.

Glass[6,9]

Five basic types of glass are currently produced: soda-lime, lead, fused silica, borosilicate, and 96 percent silica. About 90 percent of the glass produced is the soda-lime type[9] and 3 percent is the leaded type.[6] Particulate is emitted from the cullet crushing, batch mixing of initial furnace feed, and regenerative furnace. Particulate emissions from soda-lime regenerative furnaces increase with an increase in sulfate in the batch charge. The forming operations and annealing ovens are minor sources of particulate.

Control of particulate from cullet crushing and batch mixing can be effected by changes in furnace design and control of raw materials and operating procedures. Wet centrifugal scrubbers and baghouses can also be utilized for air pollution control. Stack tests show that wet centrifugal scrubbers effect 52 percent particulate reduction, whereas baghouses show collection efficiences of over 99 percent.[9] To date, however, baghouses have been installed only on small regenerative furnaces.

Particulate sampling and component analysis have been performed on a soda-lime furnace.[9] The uncontrolled particulate emission factor developed from the tests is 1.7 kilograms per 1,000 kilograms of glass produced. One baghouse catch was analyzed for lead oxide (PbO) by a spectrographic method. The amount of lead oxide found was about 0.39 percent. The uncontrolled lead emission factors for soda-lime and lead glass are shown in Table 10-3.

Ammunitions[1,6]

Lead alloyed with arsenic or antimony is used in the manufacture of lead shot, bullets, and bullet cores. Lead oxide is also used as a detonating agent. Lead emissions probably result from the iron casting pot and remelting and polishing operations. Bag filters are employed for controlling emissions polishing operations. Based on stack test data obtained from an ammunition manufacturer (sampling and analytical methods not specified) the lead emission factors from dry bag filters are presented in Table 10-3.

Bearing Metals[1]

The most common bearing metals include copper-lead alloys, bronzes, and various babbitts. The emissions of lead from melting and alloying of bearing metals are negligible (Table 10-3).

FUEL COMBUSTION

Coal[6,10,12,22-32]

Lead, like many elements, tends to be enriched in coal. Lead is present in most coals as galena (PbS), but once the coal has been ashed, the form is lead oxide.[24,30]

The most reproducible spectrochemical results for determination of lead in coal and coal ash have been from a lithium borate fusion and spectroscopic analysis.[22] The variance ratio, which is the ratio of the highest to the lowest average lead content, has been established as 3. The results are shown below:

Region	Lead content in coal (ppm)	Weight percent of lead ashing (%)
Appalachian	4 to 14	0.001 to 0.008 (0.014 to 0.332)*
Interior-Eastern	8 to 14	0.007 to 0.028
Interior-Western	4	0.003 to 0.020
Western	5 to 10	0.001 to 0.006
Northern Plains	7	0.002 to 0.006

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* Near lead ore body.

Lead in the various coal ashes has also been analyzed by a semiquantitative spectrochemical technique. The percent lead in ashed anthracite, bituminous, subbituminous, and lignite is 0.005, 0.011, 0.0025, and 0.001 percent, respectively.[22] In the studies summarized in Reference 22, lead was detected in all of the coal ashes. In another study in which anthracite was analyzed by spark-source mass spectrometry (semiquantitative), the lead content ranged from 1 to 36 parts per million with an average lead content of 11 parts per million.[23] The highest lead content in coal (36 parts per million) occurred in Appalachian coals (Pennsylvania and Virginia).

Particulate sampling (before and after control equipment) has been performed on coal-fired boilers at power plants.[6,12,25-31] Particulate samples were analyzed by optical emission spectrography (OES), flameless atomic absorption (FAA), isotope dilution spark source mass spectroscopy (IDSSMS), atomic absorption (AA, unspecified as to flame or flameless), emission spectrometry (EST), or X-ray fluorescence (XRF). Only samples analyzed by OES appear not to agree with the other analytical techniques.

The emission factors for combustion of bituminous coal presented in Table 10-4 are based on the process firing rate and the percent lead found in the particulate collected during sampling.[6,10,12,25-32] The large range of emission factors from uncontrolled coal-fired boilers could be directly related to lead content in the coal. However, part of this apparent variation is probably due to the fact that both EST and OES are semiquantitative techniques. Lead collection efficiences obtained during testing for the various types of air pollution control equipment employed on the boilers are shown in Table 10-5.

Oil[5,6,9,33-37,53,54]

Based on an unspecified analytical technique, the lead content of nearly 100 domestic crude oil samples ranged from 0.0003 to 11.4 parts per million, with an average of 0.29 parts per million.[33] The lead content of residual oils ranges from 1.7 to 4.1 parts per million.[36]

A few studies have determined the lead content in fly ash from oil-fired boilers.[35,36] Particulate matter from two residual oil-fired boilers was collected and analysed for lead by optical emission spectrometry. The emission factors for these studies are presented in Table 10-6, and are based on lead content in the particulate matter and the fuel firing rate.

Also presented in Table 10-6 are two emission factor estimates--one derived from the lead content in residual oil,[34] and the other from the lead percent found in fly ash[9] and the emission factor for particulate matter.[5] The emission factor derived from the lead content in residual oil assumes 31 percent of the lead is emitted and an oil density of 944 grams per liter of oil. The percent lead emitted is based on reported data that indicate 40 to 97 (average 69) percent of the lead remains in solid deposits in an oil-fired boiler.[34] The emission factor will be larger if soot blowing is considered.

Several studies have been completed on waste oil combustion. In Reference 34, lead contents of fuel mixtures of 1, 5, 10, 25, and 100 percent of waste oil in residual oil (Type 6) have been reported. Emission factors derived from these data are based on the lead content in the fuel mixture, assumed boiler deposit of input lead of about 69 percent, and oil densities from Reference 37.

Gasoline[38-46,55]

Lead is added to gasoline as an antiknock agent. It effectively raises the octane level of gasoline at a minimum cost to the refiner. Because lead in the environment is considered a health hazard, the lead content in gasoline has been regulated by EPA. In the past, commerical gasoline lead content has been as high as 3 grams of lead per gallon of gasoline. In order to reduce the lead load on the environment, EPA has promulgated maximum allowable gasoline lead content limits, as follows:[38]

	Large refineries* (g Pb/gal.)	Small refineries** (g Pb/gal.)
April 1976	1.70	2.56
After January 1, 1978	0.8	***
After October 1, 1979	0.5	***

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* Large refinery, capacity greater than 10,000 barrels crude oil per day.

** Small refinery, capacity less than 10,000 barrels crude oil per day.

*** Regulations to be promulgated at a later date.

The average national lead content of gasoline as of April 1976 is stated in Reference 38 to be 1.72 grams of lead per gallon of gasoline. This figure will be reduced to 0.5 grams of lead per gallon of gasoline in 1979. Many newer model motor vehicles (i.e., equipped with catalytic convertors) are unable to use leaded gasoline. Instead, these vehicles must use unleaded gasoline, which currently has a lead content of 0.04 grams lead per gallon.[46] In the future, as more of these vehicles are on the road, the lead load upon the environment should be lessened.

The testing of automobile exhaust for lead particulate has been fairly well documented.[39-46] The lead emitted in automobile exhaust is a function of the lead content of the gasoline, mode of vehicle operation, and age and mileage of the vehicle. As vehicle speed increases, lead emissions rise; and as a vehicle ages, the amount of lead emitted relative to the amount which remains in the exhaust system also rises. The emission factors for various vehicles and driving modes are listed in Table 10-7.

All engines and automobiles were tested using a dynamometer, but particulate collection techniques varied from study to study. In References 39 and 40, an electrostatic precipitator was employed for the entire exhaust stream resulting in a reported lead collection efficiency of 90 to 95 percent. Isokinetic sampling and total exhaust filter sampling were used in studies done in Reference 41. The total filter exhaust techniques gave a lead collection efficiency of greater than 99 percent. In Reference 42, a large polyethylene bag trapping technique was used. Particulates were sampled from the bag by filtration, and the bag also prevented any photochemical reactions which might cause secondary particulate formation. References 41 and 44 used an Andersen sampler (particle size) and a backup filter.

The elemental analysis for lead was not well-defined in any of the studies. Wet chemical methods were used in References 39, 40, and 42. Atomic absorption was also used for lead analyses in Reference 42; and electron probe was used in Reference 45; and X-ray diffraction in References 39, 40, and 45. Table 10-8 presents the results of analyses, by X-ray diffraction, of lead compounds from collected auto exhaust particulates.[39,40]

The emission factors in Table 10-7 are in equation form and are based on the lead content of the gasoline. Emission factor equations are given for each study because they offer more flexibility to a potential user. Also, equations were used instead of emission factor numbers because the lead content in gasolines and automobile mileages will continue to vary in future years.

Lead emissions from vehicles can be projected for future years based on the following formula:

$$\frac{[EF/100] \times PB \times ADT}{MPG \times 1609.4 \times 24 \times 3600} = \text{Emission Rate} \qquad \text{Eq. (10-1)}$$

where Emission Rate = grams per meter per second
EF = Emission Factor derived from Figure 10-8 based on vehicle speed (%)
PB = Lead content of gasoline (g/gal)
ADT = Average daily traffic (vehicles per day)
MPG = Fuel economy (miles per gallon)
1609.4 = Constant; 1 mile = 1,609.4 meters
24 = Constant; 1 day = 24 hours
3600 = Constant; 1 hour = 3,600 seconds

Projected lead emissions emanating from vehicles using seven different roadway configurations are given in Table 10-9. The values presented in the table are corrected for gasoline efficiency at the vehicle speed designated. The data are projected lead emission rates from 1974 to 1995. These rates decline from 1974 to 1995 because of the lower lead content of gasoline and the increased gasoline combustion efficiencies which are assumed for this time period.

An estimated evaporation for lead as TEL from automotive fuel systems and gasoline handling operations is provided in Reference 56. This emission factor, which does not cover gasoline storage losses, is given in Table 10-7.

SOLID WASTE INCINERATION[6,47,48]

There are two main types of sewage sludge incinerators: multiple hearth and fluidized beds. Scrubbers are used to control emissions. Municipal incinerators have used settling chambers, settling chambers combined with water spray, wetted baffles, mechanical collectors, scrubbers, electrostatic precipitators, and fabric filters as controls for lead oxide emissions. Emission factors for sewage sludge and municipal incineration are given in Table 10-10.

FUGITIVE DUST[22,49-52]

Lead concentrations in emissions from fugitive dust sources such as wind erosion, unpaved roads, agricultural tilling, construction sites, aggregate storage sites, etc., have not been reported. The percent lead in the earth's crust is reported to be about 0.001 percent,[22] and the percent lead in city soil dust is reported to be about 0.02 percent.[49] The soil content in total ambient particulate matter collected over an 11-day period at a particular sampling site was found to be 20 percent.[49]

An equation for particulate emissions from wind erosion of soils is provided in Reference 50.

$$E = 0.0089 \frac{asV}{(P\text{-}E/50)^2} f \qquad \text{Eq. (10-2)}$$

where E = emissions of suspended dust, tons per acre

a = soil erodibility, tons per acre per year

s = percent silt content (particles smaller than 75 micrometers in diameter) of surface material, dimensionless

V = mitigative fractional reduction in wind erosion due to vegetative cover, dimensionless

f = fraction of time wind exceeds the threshold value (12 miles per hour) for wind erosion

P-E = Thornthwaite's Precipitation-Evaporation Index[51]

To obtain lead emissions from natural wind erosion, the percent lead in soil silt fraction could be applied to this equation.

Particulate emission factors for emissions from unpaved roads, agricultural tilling, and aggregate storage piles have been developed.[51,52] The particulate emission factor equations are shown below:

Unpaved Roads: $E = 0.49s(S/30)(d/365)$ pounds per vehicle-mile Eq. (10-3)

Agricultural Land Tilling: $E = \frac{1.1s(S/5.5)}{(P\text{-}E/50)^2}$ pounds per acre tilled Eq. (10-4)

Construction: $E = D$ pounds per acre of active construction Eq. (10-5)

Aggregate Storage Piles: $E = \frac{0.33}{(P\text{-}E/100)^2}$ pounds per ton put through storage   Eq. (10-6)

where E = emission factor (units as specified)

s = surface silt content (percent)

S = vehicle or implement speed (miles per hour)

d = number of dry days per year

P-E = Thornthwaite's Precipitation-Evaporation Index[51]

D = average duration of construction projects (months)

Emission factors for lead may be estimated by multiplication of the above factors by the fraction of lead in the surface silt. A correction would have to be applied to Eq. (10-3) to account for elevated lead levels in the dust on unpaved roads resulting from vehicle exhaust.

OTHER INDUSTRIAL/AGRICULTURAL SOURCES[1,5,9,10,12]

Lead is used in the production of ceramics, plastics, fusible alloys, powdered lead greases, metal deposition, and pesticides. Lead is also recovered from sweating furnaces. Lead is present in feed materials in mineral wool manufacturing, frit smelters, automobile body incineration, phosphate rock processing, coal cleaning, and fly ash sintering. Other potential sources of lead are agricultural burning and pesticide application, wood combustion, phosphoric acid production, detergents, phosphate fertilizer production and application, sugar cane processing, sand gravel production, perlite manufacturing, coke production, and stone crushing. No emission data or limited data were reported to develop emission factors for lead from the above mentioned possible sources.

There is a possibility that lead contamination of cotton fields will lead to lead emissions during cotton processing. In tests made on a cotton gin operation the lead content of material before entering a scrubber was 0.1 percent but was below detectable limits after passing through the control device.[12]

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Table 1-1. EMISSION FACTOR SYMBOLS

Emission factor symbol	Technique	Estimated precision
PV	Plant visits	Unknown.
E	Engineering judgment	Unknown.
Q	Questionnaire surveys	Unknown.
MB	Material balances	Unknown.
Source sampling		
AA	Atomic absorption	See flame and flameless below (CAA and FAA, respectively).
CAA	Flame atomic absorption	Precision is 1, 3, and 10 percent for minimum detectable levels of 1, 0.3, and 0.1 parts per million, respectively, for beryllium and for nickel in oil samples. Minimum detectable level is 0.5 parts per million for cadmium in oil samples. Minimum detection limit is 0.001 micrograms per milliliter of prepared sample for cadmium generally. Less precise than FAA for mercury.
DH	Dithizone	Comparable to FAA for mercury analysis.
EP	Electron probe	Precision ± 10%
ES	Emission spectroscopy	Semiquantitative.
EST	Emission spectrometry	Semiquantitative.
FAA	Flameless atomic absorption	± 1 percent with minimum resolution of 2 parts per billion for analysis of mercury.
IDSSMS	Isotope dilution spark source mass spectroscopy	Mass balance using this technique was within ± 15% for lead for a coal fired boiler. Results for coal and flyash were less than 10% with NBS coal and flyash standards.
NA	Neutron activation	± 25 percent for one sample of particulate analyzed. Arsenic in biological materials had an average deviation of about ± 6.7 percent. ± 10 percent precision for mercury in coal. Precision of ± 3 percent for biological tissues analyzed for cadmium.
OES	Optical emission spectrography	Considered to be semiquantitative. Reported to have a precision of ± 25 percent for samples from cement plants.
S	Saltzman's colorimetric	Unknown.
SC	Spectrochemical analyses	Limit of detection is 0.0001 percent with a precision of ± 11 percent for beryllium analysis in coal.
SSMS	Spark source mass spectrography	Precision ± 100 percent.
UN	Unknown, reported in literature based on unspecified analytical technique	Unknown.
W	Wet chemical method	Precision ± 10%.
XRD	X-ray diffraction	Precision ± 10%.
XRF	X-ray fluorescence	Lead analysis in flyash samples agreed within ± 30% of an NBS flyash standard.

Table 10-1. EMISSION FACTORS FOR LEAD FROM MINING AND PRIMARY METALLURGICAL INDUSTRIAL SOURCES

Source	Emission factors[b] kg/10³kg	Emission factors[b] lb/ton	Emission factor symbol[c]	Reference
Mining and milling[d]	0.1 (0.006-0.15)	0.2 (0.012-0.3)	E	1, 6
Primary lead smelting[e]				
Auxiliary operations[f]	2.2 (1.4-3.5)	4.4 (2.8-6.9)	CAA (3)	3, 4
	2.1 (1.3-3.2)	4.1 (2.6-6.4)	CAA (3)	3, 4
Sinter machine	4.7 (2.2-8.7)	9.5 (4.5-17)	CAA (3)	3, 4
	4.4 (2.1-8.1)	8.8 (4.2-16)	CAA (3)	3, 4
Blast furnace	11 (7.3-16)	23 (15-31)	CAA (3)	3, 4
	10 (6.6-14)	21 (13-28)	CAA (3)	3, 4
Blast furnace[g]	0.23 (0.099-0.34)	0.45 (0.20-0.67)	CAA (3)	3, 4
	0.20 (0.093-0.30)	0.41 (0.19-0.60)	CAA (3)	3, 4
Primary lead smelting[h]				
Dross reverberatory	2.4 (1.3-3.5)	4.8 (2.6-7)	UK	6
Sinter machine	87.1 (4.2-170)	174.2 (8.4-340)	UK	6
Blast furnace	29.3 (8.7-50)	58.8 (17.5-100)	UK	6
Copper smelting[i]				
Roasting	1.2P[j]	2.3P[j]	UK	6
Reverberatory furance	0.83	1.7	UK	6
Roasting and reverberatory furance[k]	0.03	0.06	E, FAA	4, 5
Converting	1.3	2.6	UK	6
Converting[l]	0.3	0.6	E, FAA	4, 5
Zinc smelting				
Sintering	19.3 (13.5-25)	38.5 (27-50)	UK	6
Vertical retort	2.2 (2-2.5)	4.5 (4-5)	UK	6
Horizontal retort	1.2	2.4	UK	6

---

[a] Uncontrolled unless otherwise specified.

[b] Emission factor conversion from one set of units to another set of units by a user cannot always be done because the emission factors have been rounded to one or two significant figures.

[c] Defined in Table 1-1.

[d] Emission factor expressed as unit per unit of lead in ore.

[e] Emission factor (first row of numbers) expressed as units per unit of lead produced, and (second row of numbers) expressed as units per unit of lead processed.

[f] Operations consist of two cleanup conveyors, sinter breaker, spiked roll, conveyor, and collecting drum.

[g] Water spray chamber and baghouse exit (emission factor based on continuous plant monitor).

[h] Emission factor expressed as units per unit of lead produced.

[i] Emission factor expressed as units per unit of concentrated ore charged.

[j] P = lead content in copper concentrate in percent by weight. Average lead content for U.S. concentrates is 0.3 percent. Emission factor for copper operations are expressed as pounds per ton (grams per kilogram) concentrate ore.

[k] Exit from an ESP with a reported MMPD of about 0.3 micrometer for particulate matter.

[l] Exit from an ESP with a reported MMPD of 3.0 micrometers for particulate matter.

Table 10-2. EMISSION FACTORS FOR LEAD FROM SECONDARY METALLURGICAL RECOVERY AND OTHER INDUSTRIAL SOURCES

Source[a]	Emission factors[b]		Emission factor symbol[c]	Reference
	kg/10³ kg	lb/ton		
Secondary lead[d]				
Blast furnace (uncontrolled)	28 (11-48)	56 (22-97)	CAA (6)	6, 7
Blast furnace[e]	0.019 (0.0089-0.032)	0.037 (0.018-0.063)	CAA (6)	7
Blast furnace[f]	0.043 (0.028-0.055)	0.085 (0.056-0.11)	CAA (3)	8
Blast furnace[g]	0.0048 (0.0034-0.0075)	0.0096 (0.0067-0.015)	CAA (3)	8
Blast furnace[h]	0.013	0.026	CAA (3)	8
Reverberatory furnace	27	53	UR	6
Slag tap blast furnace (uncontrolled)	0.45 (0.21-0.65)	0.90 (0.42-1.3)	CAA (3)	7
Refining kettles	0.10	0.21	CAA (3)	7
Refining kettles and slag tap[i]	0.012	0.023	CAA (3)	7
Steel production[j]				
Sintering	0.0067[k]	0.013[k]	UR	6
Coking	0.0018[l]	0.0035[l]	UR	6
Blast furnace	0.062	0.12	UR	6
Open-hearth furnace	0.07	0.14	UR	6
Oxygen lance	0.1 (0.03-0.2)	0.2 (0.07-0.4)	E, UR, EE (1)	1, 5, 9, 11
No oxygen lance	0.2 (0.07-0.4)	0.3 (0.1-0.9)	E, UR, EE (1)	1, 5, 9, 11
Basic oxygen furnace	0.1	0.2	UR	6
Electric arc furnace	0.11	0.22	UR	6
Oxygen lance	0.04	0.08	E, UR	1, 5
Oxygen lance	0.1	0.3	FAA (1)	12
Oxygen lance[m]	0.003	0.006	FAA (1)	12
Gray iron foundry[n]				
Cupola	0.3	0.6	UR	6
Electric induction	0.026	0.05	UR	6
Reverberatory furnace	0.035	0.07	UR	6
Brass and bronze[n]				
Crucible[m]	0.03	0.06	E, CAA (7)	5, 9, 13, 16
Electric induction[m]	0.03	0.06	E, CAA (7)	5, 13, 16
Rotary[m]	0.05	0.1	E, CAA (7)	5, 13, 16
Reverberatory furnace[m]	0.05	0.1	E, CAA (7)	5, 13, 16
High lead alloys	25	50	UR	6
Red and yellow brass	6.6	13.2	UR	6
Other alloys	1.5	3.0	UR	6
Ferroalloys[o]				
Electric arc furnaces[p]				
Silicomanganese	0.41	0.83	EBD	1, 5, 6
Silicon metal	0.0008	0.0016	EBD	5, 6, 15, 16
Standard ferromanganese	0.3	0.6	EBD	1, 5, 6
Blast furnace	1.9	3.7	EBD	1, 5, 6
Cement plants[q]				
Dry process[r]				
Kilns - 2[s]	0.08 (10⁻³)	0.2 (10⁻³)	EE (1)	17
Kiln/cooler	0.06	0.11	UR	6
Dryers/grinders	0.03	0.06	UR	6
Air separator after raw mill[m]	0.001 (10⁻³)	0.002 (10⁻³)	EE (1)	17
Feed to raw mill[m]	0.003 (10⁻³)	0.005 (10⁻³)	EE (1)	17
Total	0.08	0.15	UR	6

Table 10-2. (continued)

Source[a]	Emission factors[b] kg/10³ kg	Emission factors[b] lb/ton	Emission factor symbol[c]	Reference
Wet process				
Kiln[r]	1 (10^{-3})	2 (10^{-3})	ES (2)	18
Kiln/cooler	0.05	0.10	UR	6
Dryers/grinders	0.01	0.02	UR	6
Clinker cooler[m,t]	0.03 (10^{-3})	0.06 (10^{-3})	ES (2)	18
Finishing mill[m]	0.6 (10^{-3})	1 (10^{-3})	ES (1)	18
Total	0.6	0.12	UR	6

---

[a] Uncontrolled unless otherwise specified.

[b] Emission factor conversion from one set of units to another set of units by a user cannot always be done because the emission factors have been rounded to one or two significant figures.

[c] Defined in Table 1-1.

[d] Emission factor expressed as units per unit of lead produced.

[e] Afterburner, settling chamber, cooling system, and baghouse exit (lead collection efficiency of 99.9 percent).

[f] Settling chamber, venturi scrubber, and demister unit.

[g] Afterburner, water spray, cooling system, baghouse, venturi scrubber, and mist eliminator exit.

[h] Afterburner, three cyclones, and baghouse exit (front half of EPA train only).

[i] Exit from a venturi scrubber and a cyclone.

[j] Emission factor expressed as units per unit of steel produced.

[k] Units are in grams per kilogram of sinter produced (pounds per ton).

[l] Units are in grams per kilogram of coal consumed (pounds per ton).

[m] Exit from a baghouse.

[n] Emission factor expressed as units per unit of metal produced.

[o] Emission factor expressed as units per unit weight of ferroalloy (silicomanganese, silicon metal).

[p] X-ray diffraction analysis used.

[q] Emission factor expressed as units per unit weight of feed to the process.

[r] Lead content was below the detectable limits of ES for samples collected from raw mill, finish mill, and feed to finish mill.

[s] Multiclone and two baghouses exit.

[t] Exit from an electrostatic precipitator.

[u] Lead content from another clinker cooler (controlled by ESP) was below the detectable limit of ES.

Table 10-3. EMISSION FACTORS FOR LEAD FROM INDUSTRIES PROCESSING AND UTILIZING LEAD AND ITS COMPOUNDS

Source[a]	Emission factors[b]		Emission factor symbol[c]	Reference
	kg/10^3 kg	lb/ton		
Lead oxide production[d]				
Barton pot[e]	0.22 (0.16-0.33)	0.44 (0.31-0.70)	CAA (3)	8, 19
	0.24 (0.17-0.38)	0.47 (0.33-0.75)	CAA (3)	19
Calcining furnace, hammermill, and surge hopper	7	14	CAA (2)	19
Calcining furnace, hammermill, and surge hopper[f]	0.024 (0.011-0.033)	0.047 (0.023-0.066)	CAA (3)	19
Lead oxide[f]	0.22	0.44	UR	6
Storage battery production				
Casting furnace[g]	0.081	0.162	CAA (3)	20
Casting furnace[h]	0.11	0.23	UR	6
Paste mixer[h]	1.13	2.26	UR	6
Paste mixer[i]	0.017	0.033	CAA (3)	20
Lead oxide mill[h]	1.13	2.30	UR	6
Stacking, burning, and assembly[h]	0.9	1.8	CAA (3)	20
Stacking, burning, and assembly[h]	0.78	1.55	UR	6
Lead reclaim furnace[l]	0.05	0.10	UR	6
Grid casting[h]	0.33	0.66	UR	6
Small parts casting[h]	0.05	0.10	UR	6
Gasoline additives[j]				
Lead recovery furnace	28	55	Q, UR	6
Pot furnace	0.4	0.8	Q, UR	6
TEL process vents	4.0	8.0	UR	6
TML process vents	75	150	UR	6
Sodium lead alloy sludge pit	0.6	1.2	UR	6
Electrolytic process[k]	0.5	1	Q	1, 6
Cable covering[g]				
Ferrille lead melt pot	0.015 (0.0071-0.029)	0.03 (0.014-0.058)	CAA (3)	21
Melting kettle	0.25	0.5	UR	6
Lead pigments[j]	5	10	Q	1
White lead[f]	0.28	0.55	UR	6
Red lead[l]	0.5	0.9	UR	6
Chrome pigments	0.065	0.13	UR	6
Paint manufacture[m]	100	200	Q	1, 3
Lead solders				
Can soldering[n]	0.08	0.16	UR (3)	6
Lead solder melt pot	0.0011	0.0022	AA (3), UR (4)	5
Type metal[g]	0.13	0.25	UR	6
Metallic lead[g]	0.75	1.5	Q	1, 6
Glass manufacture[o]				
Soda-lime[l]	0.005	0.01	B, UR3 (1)	9
Lead	2.5	5.0	UR	6
Ammunition[p]	0.5	1.0	UR	6
Bearing metals	Negligible	Negligible	Q	1, 6

---

[a] Uncontrolled unless otherwise specified.

[b] Emission factor conversion from one set of units to another set of units by a user cannot always be done because the emission factors have been rounded to one or two significant figures.

[c] Defined in Table 1-1.

[d] Settling chamber, cyclone, and baghouse exit.

[e] Emission factor expressed as units per unit of lead product; second row of numbers for Barton pot expressed as units per unit of lead processed.

[f] Cyclone and baghouse exit.

[g] Emission factor expressed as units per unit of lead processed.

[h] Emission factor expressed as units per 10^3 batteries produced.

[i] Emission factor expressed as units per unit lead oxide processed.

[j] Emission factor expressed as units per unit of lead produced.

[k] Two process stacks at plant. Flare stack gases are scrubbed in two packed column units; furnace stack uncontrolled.

[l] Baghouse exit.

[m] Emission factor expressed as units per unit of pigment processed (X = lead content in pigment by weight fraction).

[n] Units in Mg of lead (ton) per million base boxes.

[o] Emission factor expressed as unit per unit glass produced.

[p] Emission factor expressed as grams per milligram lead processed (pounds per 10^3 ton).

Table 10-4. EMISSION FACTORS FOR LEAD FROM COAL COMBUSTION

Source[a]	Lead content (ppm)	Emission factor[b,c] kg/10^6 kg	Emission factor[b,c] lb/10^3 ton	Emission factor symbol[d]	Reference
Power plant:					
Boiler, uncontrolled	–	0.05 (0.009–0.2)	0.1 (0.02–0.4)	OES (6)	27
Boiler, uncontrolled	4.7 (2.1–7.4)[e]	3.2 (1.5–6.3)	6.5 (3–13)	FAA (4), IDSSMS (2)	12, 25, 26
Pulverized-fired utility boiler, uncontrolled	8.3	0.8P[f]	1.6P[f]	UK	6
Cyclone-fired utility boiler, uncontrolled	8.3	0.8P[f]	1.6P[f]	UK	6
Boiler, uncontrolled	5	1	2	E, XRF (3)	30
Boiler, ESP and scrubber[l]	–	0.04	0.08	OES (1)	27
Boiler, 150 MW[g]	–	8	16	E, AA (1)	31
Boiler, 30 MW[g]	–	4	8	E, AA (1)	31
Boiler[g]	3.7	2	3	FAA (1)	26
Boiler[h]	–	0.002	0.004	OES (2)	27
Boiler[i,j]	<3	0.008–1	0.02–2	OES (2), ESI (5)	27, 29
Boiler[i]	–, 8.2	0.1 (0.02–0.2)	0.2 (0.05–0.3)	FAA (1), IDSSMS (2)	12, 25
Boiler[k]	100	0.9	2	ESI (2)	28, 29
Boiler[l]	–	0.04	0.07	XRF (1)	30

[a] Uncontrolled unless otherwise specified.

[b] Emission factor conversions from one set of units to another set of units by a user cannot always be done because the emission factors have been rounded to one or two significant figures.

[c] Emission factor expressed as units per unit of coal burned.

[d] Defined in Table 3-1.

[e] Based on data from References 25 and 26; no lead determination was reported in Reference 12.

[f] Multiply this emission factor per parts per million by the lead content in the coal (P in parts per million) to obtain the gross emission factor.

[g] Mechanical collector exit.

[h] Cyclone and electrostatic precipitator exit.

[i] Electrostatic precipitator exit.

[j] Below the detectable level of the analytical technique (ESI).

[k] Wet limestone scrubber

[l] Exit from cyclone and electrostatic precipitator and scrubber in parallel.

Table 10-5. COLLECTION EFFICIENCIES FOR LEAD FROM COAL-FIRED BOILERS

Control equipment[a]	Lead collection (%)	Analysis for lead	Reference
C and ESP	81 (67-95)	OES (2)	27
ESP	91	OES (1)	27
ESP and FAR	81	OES (1)	27
C	0	OES (1)	27
C and FAR	79	OES (1)	27
ESP	99	FAA (1)	12
C, and ESP and WS (parallel)	70	E, XRF (3)	30
ESP	97	IDSSMS (2)	25
C	29	FAA (3)	26

[a] C=mechanical collector, ESP=electrostatic precipitator, FAR=fly ash reinjection, WS=wet scrubber.

Table 10-6. EMISSION FACTORS FOR LEAD FROM OIL COMBUSTION

Source[a]	Lead content (ppm)	Emission factors[b,c] kg/10³ liters	Emission factors[b,c] lb/10³ gal.	Emission factor symbol[d]	Reference
Typical residual fired boiler	1.0 (up to 1.0)	0.0005P[e]	0.0042P[e]	UK	6
Typical distillate fired boiler	0.1 (0.1 to 0.5)	0.0005P[e]	0.0042P[e]	UK	6
Power plant, residual oil[f]	-	0.1	1	ES (2)	35
Commercial unit, residual oil	-	0.0002	0.002	OES (3)	36
Residential unit (distillate oil)	-	0.0006	0.005	OES (3)	36
Residual oil	1.7-4.1	0.0005-0.001	0.004-0.01	E, UK	34
Residual oil	-	0.005	0.04	E, OES (1)	5, 9
1% W.O. and 99% R.O.[g]	63	0.02	0.2	E, UK	34, 37
5% W.O. and 95% R.O.	305	0.1	0.8	E, UK	34, 37
10% W.O. and 90% R.O.	603	0.2	2	E, UK	34, 37
25% W.O. and 75% R.O.	1,502	0.5	4	E, UK	34, 37
Waste oil	6,000	1	10	E, UK	34, 37
Waste oil[h]	-	7 (5-8)	60 (40-70)	UK (9)	53
Waste oil	0.6 to 11	4.0M[i]	40M[i]	UK	6
75% W.O. and 25% R.O.	7,000 (6,700-7,200)	2 (1-2)	20 (10-30)	UK (9)	54
Soot blowing	7,000 (6,700-7,200)	5	40	UK (1)	54
25% W.O. and 75% R.O.	-	0.7	6	AA (7)	54

[a] Uncontrolled emissions unless otherwise specified.

[b] Emission factor expressed in units per unit of oil burned.

[c] Emission factor conversion from one set of units to another set of units by a user cannot always be done because the emission factors have been rounded to one or two significant figures.

[d] Defined in Table 1-1.

[e] Multiply this emission factor per parts per million by the lead content in the oil (P in parts per million) to obtain the gross emission factor.

[f] Exit from an electrostatic precipitator.

[g] W.O. = waste oil, R.O. = residual oil, and D.O. = distillate oil.

[h] Considered to be the "best" emission factors for burning 100% waste oil.

[i] Multiply this emission factor by the percent lead in waste oil (M) to obtain the gross emission factor.

Table 10-7. EMISSION FACTORS FOR LEAD FROM GASOLINE COMBUSTION

Source[a]	Emission factor equation[b]	Emission factor rating[c]	Reference
Six-cylinder, 1956[d]			
25 mph	0.15 G/M	M, SBD	59, 60
45 mph	0.28 G/M	M, SBD	59, 60
60 mph	0.36 G/M	M, SBD	59, 60
V-8, 1966 single exhaust[e]			
City driving after suburban driving	0.23-0.26 G/M	M, SBD	59, 60
City driving	0.50-0.60 G/M	M, SBD	59, 60
Full-throttle acceleration	12 G/M	M, SBD	59, 60
after 260 miles at 60 mph	12-1 G/M	M, SBD	59, 60
V-8, 1966 dual exhaust[f]			
City driving after suburban driving	0.20-0.23 G/M	M, SBD	59, 60
City driving	0.10-0.63 G/M	M, SBD	59, 60
Full-throttle acceleration, 20-60 mph	13 G/M	M, SBD	59, 60
after 260 miles at 60 mph	19-0.67 G/M	M, SBD	59, 60
1966, 327 C.I.D.			
25 mph	0.16 G/M	UR	61
45 mph	0.28-0.91 G/M	UR	61
70 mph	0.39-0.78 G/M	UR	61
1966, 16 per emission control vehicles (15,000-120,000 miles)[g]			
Federal 7-mode cycle			
4 Cold	0.16 G/M	M, AA (18)	62
4 Hot	0.18 G/M	M, AA (17)	62
Weighted[h]	0.17 G/M	M, AA (18)	62
1970 cars ([illegible] miles)			
Federal 7-mode cycle[g]			
4 Cold	0.13 G/M	M, AA (8)	62
4 Hot	0.16 G/M	M, AA (13)	62
Weighted[h]	[illegible] G/M	M, AA (8)	62
16 cars, 1963-1968 and 16, 1968[i]			
25 mph	0.12 G/M (0.009, 0.11)	M, AA	62
45 mph	0.18 G/M (0.06, 0.16)	M, AA	62
60 mph	0.31 G/M (0.105, 0.22)	M, AA	62
Federal cycle			
Cold	0.21 G/M (0.06, 0.15)	M, AA	62
Hot	[illegible] G/M (0.275, 0.25)	M, AA	62
Full[h]	0.29 G/M (0.11, 0.18)	M, AA	62
WOT acceleration	11 G/M (7, 4)	M, AA	62
1970, Chevrolet V-8			
35 mph	0.16-0.51 G/M	EP, XRD	63
Evaporative losses for TEL	0.005 kg/10^3 liters	E	19
AVERAGE VEHICLE EMISSION FACTOR	1.65Y[j]	UR	5

---

[a] Uncontrolled unless otherwise specified.

[b] G=kilograms of lead per liter (pounds of lead per gallon), M=gasoline mileage, kilometers per liter (miles per gallon).

[c] Defined in Table 1-1.

[d] Percent of input lead emitted less than 2 micrometers at 25, 45, and 60 miles per hour was 17, 30, and 23 percent, respectively (e.g., at 25 miles per hour the equation would be 0.13 G/M).

[e] Percent of input lead emitted less than 2 micrometers for city driving after suburban service, city driving, full-throttle acceleration 20 to 60 miles per hour, and 260 miles at 60 miles per hour was 10 to 16, 33 to 33, 782 and 780 to 41 percent, respectively.

[f] Percent of input lead emitted less than 2 micrometers for city driving after suburban service, city driving, full-throttle acceleration 20 to 60 miles per hour, and 260 miles at 60 miles per hour was 16 to 23, 20 to 33, 1,100 and 1,100 to 37.

[g] Well-established lead deposits.

[h] Thirty-five percent cold and 65 percent hot.

[i] Numbers in parentheses are based on the percent of input lead emitted that was caught in a cyclone (coarse, > 3 micrometers) and filter (fine, < 0.3 micrometer); the total emitted lead at 25 miles per hour, for example, would be 0.12 G/M = 0.009 G/M + 0.11 G/M.

[j] To obtain emission factor multiply by Y, Y = lead content in gasoline in grams per gallon. Resulting emission factor units are pounds per 10^3 gallons of gasoline. (Y in 1976 averaged 1.7 grams per gallon.)

Table 10-8. WEIGHT PERCENT OF LEAD COMPOUNDS IN COLLECTED PARTICULATE

	$PbClBr$	$\alpha NH_4Cl\cdot 2PbClBr$	$\beta NH_4Cl\cdot 2PbClBr$	$2NH_4Cl\cdot PbClBr$	$3Pb_3(PO_4)_2\cdot PbClBr$
Single exhaust					
City-type driving, fuel + TEL only	68	24	6	2	-
Constant speed, 60 mph	60	20	20	-	-
Full-throttle accelerations	85	10	5	-	-
City-type driving, added phosphorus	35	18	17	10	20
Dual exhaust					
City-type driving, fuel + TEL only	33	40	5	22	-
Constant speed, 60 mph	30	30	35	5	-
Full-throttle accelerations	90	10	-	-	-

Table IV-4. LEAD EMISSIONS FOR VARIOUS ROADWAY CONFIGURATIONS[22]

Parameter								
Driving cycle		Highway	Composite	Highway	City	Highway	City	Highway/City[a]
Average speed (mph)		60	30	48	26	38	26	60/0-45
ADT (vehicle/day)		50,000	5,000	116,350	26,000	108,000	26,000	61,000/24,300
Emission factor fraction		0.54	0.22	0.425	0.105	0.30	0.365	0.54/25.0
Area	**Year**	Emission rates (g/m - sec)						
48 States	1976	1.94 x 10^{-5}	1.94 x 10^{-6}	1.29 x 10^{-5}	4.25 x 10^{-6}	2.33 x 10^{-5}	1.47 x 10^{-5}	3.80 x 10^{-4}
	1977	9.08 x 10^{-6}	4.67 x 10^{-7}	1.52 x 10^{-5}	1.97 x 10^{-6}	1.09 x 10^{-5}	6.84 x 10^{-6}	1.78 x 10^{-4}
	1978	6.94 x 10^{-6}	3.73 x 10^{-7}	1.25 x 10^{-5}	1.49 x 10^{-6}	8.29 x 10^{-6}	5.20 x 10^{-6}	1.35 x 10^{-4}
	1979	4.07 x 10^{-6}	2.19 x 10^{-7}	6.89 x 10^{-6}	8.86 x 10^{-7}	4.89 x 10^{-6}	3.08 x 10^{-6}	7.96 x 10^{-5}
	1980	3.84 x 10^{-6}	2.06 x 10^{-7}	6.51 x 10^{-6}	8.35 x 10^{-7}	4.60 x 10^{-6}	2.89 x 10^{-6}	7.59 x 10^{-5}
	1981	3.59 x 10^{-6}	1.93 x 10^{-7}	6.08 x 10^{-6}	7.80 x 10^{-7}	4.30 x 10^{-6}	2.71 x 10^{-6}	7.08 x 10^{-5}
	1983	1.58 x 10^{-6}	8.48 x 10^{-8}	2.68 x 10^{-6}	3.43 x 10^{-7}	1.89 x 10^{-6}	1.19 x 10^{-6}	3.11 x 10^{-5}
	1985	8.27 x 10^{-7}	4.47 x 10^{-8}	1.42 x 10^{-6}	1.81 x 10^{-7}	1.00 x 10^{-6}	6.29 x 10^{-7}	1.63 x 10^{-5}
	1990	2.30 x 10^{-7}	1.24 x 10^{-8}	3.90 x 10^{-7}	5.00 x 10^{-8}	2.76 x 10^{-7}	1.73 x 10^{-7}	4.50 x 10^{-6}
	1995	2.20 x 10^{-7}	1.18 x 10^{-8}	3.73 x 10^{-7}	4.79 x 10^{-8}	2.64 x 10^{-7}	1.67 x 10^{-7}	4.30 x 10^{-6}
California	1976	1.69 x 10^{-5}	9.45 x 10^{-7}	2.37 x 10^{-5}	3.92 x 10^{-6}	2.08 x 10^{-5}	1.36 x 10^{-5}	3.51 x 10^{-4}
	1977	7.87 x 10^{-6}	4.41 x 10^{-7}	1.36 x 10^{-5}	1.83 x 10^{-6}	9.68 x 10^{-6}	6.35 x 10^{-6}	1.64 x 10^{-4}
	1978	5.96 x 10^{-6}	3.35 x 10^{-7}	1.03 x 10^{-5}	1.39 x 10^{-6}	7.38 x 10^{-6}	4.83 x 10^{-6}	1.24 x 10^{-4}
	1979	3.54 x 10^{-6}	1.98 x 10^{-7}	6.07 x 10^{-6}	8.20 x 10^{-7}	4.36 x 10^{-6}	2.85 x 10^{-6}	7.35 x 10^{-5}
	1980	3.33 x 10^{-6}	1.87 x 10^{-7}	5.73 x 10^{-6}	7.73 x 10^{-7}	4.11 x 10^{-6}	2.69 x 10^{-6}	6.92 x 10^{-5}
	1981	3.12 x 10^{-6}	1.74 x 10^{-7}	5.38 x 10^{-6}	7.23 x 10^{-7}	3.84 x 10^{-6}	2.51 x 10^{-6}	6.48 x 10^{-5}
	1983	1.37 x 10^{-6}	7.67 x 10^{-8}	2.36 x 10^{-6}	3.17 x 10^{-7}	1.69 x 10^{-6}	1.10 x 10^{-6}	2.85 x 10^{-5}
	1985	7.27 x 10^{-7}	4.05 x 10^{-8}	1.25 x 10^{-6}	1.68 x 10^{-7}	8.94 x 10^{-7}	5.84 x 10^{-7}	1.51 x 10^{-5}
	1990	2.59 x 10^{-7}	1.12 x 10^{-8}	3.44 x 10^{-7}	4.64 x 10^{-8}	2.46 x 10^{-7}	1.62 x 10^{-7}	4.15 x 10^{-6}
	1995	2.41 x 10^{-7}	1.07 x 10^{-8}	3.29 x 10^{-7}	4.43 x 10^{-8}	2.36 x 10^{-7}	1.55 x 10^{-7}	3.97 x 10^{-6}

---

[a] Represents combination of highway portion and acceleration portion (city) of an expressway ramp.

Table 10-11. EMISSION FACTORS FOR LEAD FROM SOLID WASTE INCINERATION

Source[a]	Emission factors[b,c]		Emission factor symbol[d]	Reference
	kg/10³ kg	lb/ton		
Sewage sludge				
Multiple hearth[e]	0.02 (0.01-0.02)	0.03 (0.02-0.05)	OES (A)	1, 47
Fluidized bed[e]	0.0005 (0.0005-0.002)	0.001 (0.0001-0.003)	OES (C)	1, 47
Municipal incineration				
Uncontrolled	0.2 (0.15-0.25)	0.4 (0.03-0.5)	EST (C), EK	6, 48
After electrostatic precipitator	0.03	0.06	EST (C)	48

[a] Uncontrolled unless otherwise specified.

[b] Emission factor conversion from one set of units to another set of units by a user cannot always be done because the emission factors have been rounded to one significant figure.

[c] Emission factor expressed as units per unit of solid waste (sludge waste) burned.

[d] Defined in Table 1-1.

[e] Exit from a wet scrubber. Lead ratio of metal in particulate to metal in sludge range from 0.1 to 4.5 with an average of 2.6.

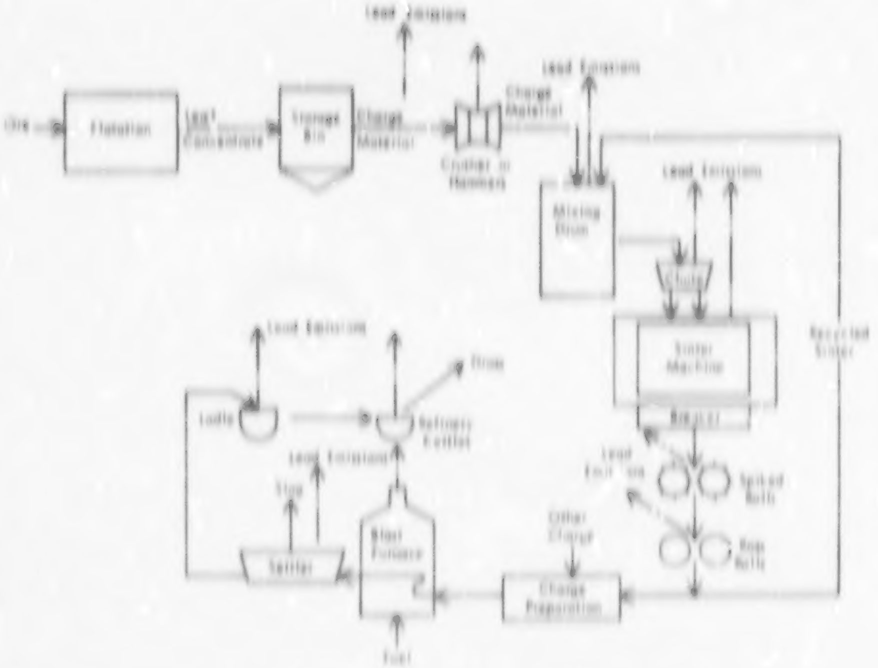
Lead Emissions
Ore
Flotation
Lead Concentrate
Storage Bin
Charge Material
Crusher or Hammers
Charge Material
Lead Emissions
Mixing Drum
Lead Emissions
Chute
Sinter Machine
Recycled Sinter
Lead Emissions
Dross
Ladle
Refinery Kettles
Lead Emissions
Slag
Settler
Blast Furnace
Other Charge
Charge Preparation
Spiked Rolls
Fuel

Figure 10-1. Primary Lead Smelter Schematic[1]

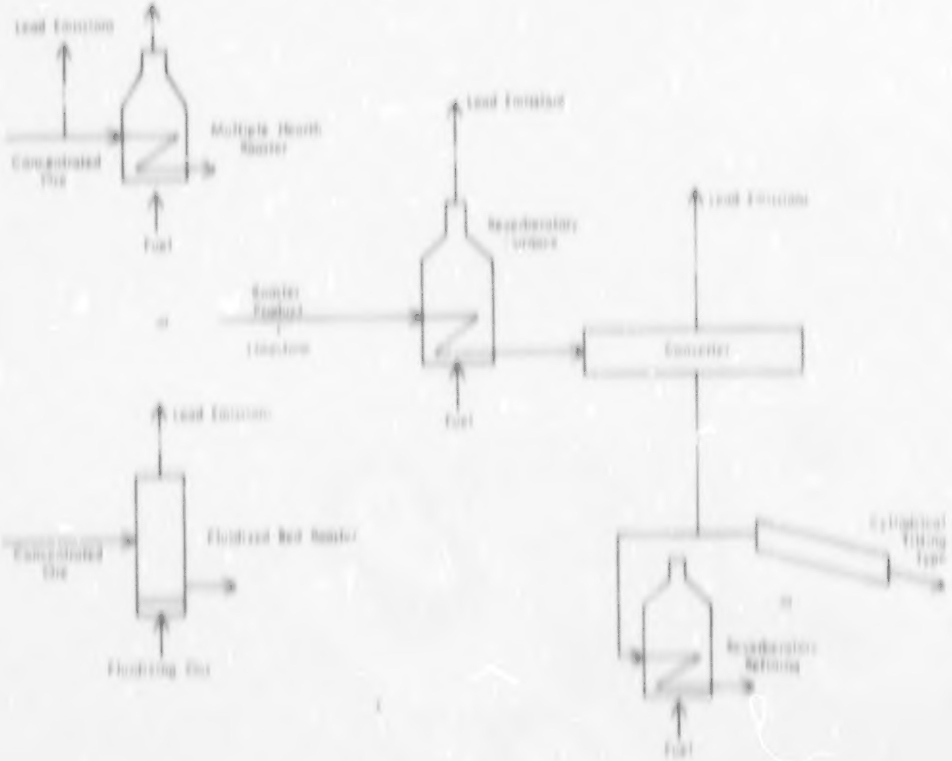
Lead Emission
Multiple Hearth Roaster
Concentrated Ore
Fuel
Lead Emission
Reverberatory Furnace
Roaster Product
Limestone
or
Fuel
Lead Emission
Converter
Lead Emission
Fluidized Bed Roaster
Concentrated Ore
Fluidizing Gas
Cylindrical Tilting Type
or
Reverberatory Refining
Fuel

Figure 10-2. Primary Copper Smelter Schematic[1]

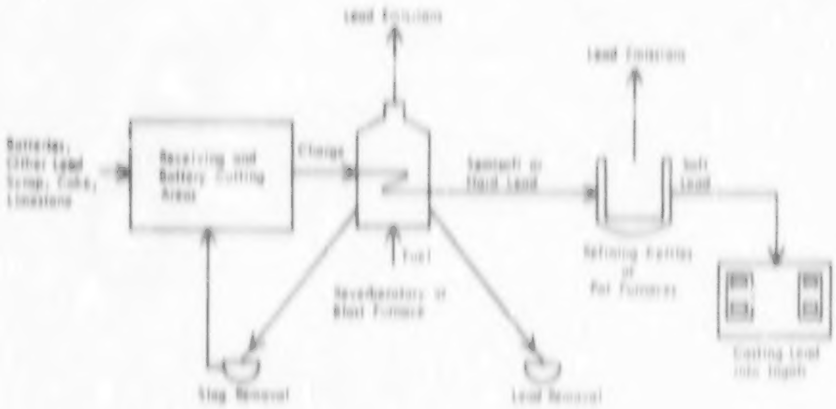
Lead Emissions
Lead Emissions
Batteries, Other Lead Scrap, Coke, Limestone
Receiving and Battery Cutting Areas
Charge
Sweated or Hard Lead
Soft Lead
Fuel
Reverberatory or Blast Furnace
Refining Kettles or Pot Furnaces
Casting Lead into Ingots
Slag Removal
Lead Removal

Figure 10-3. Secondary Lead Production Schematic[1]

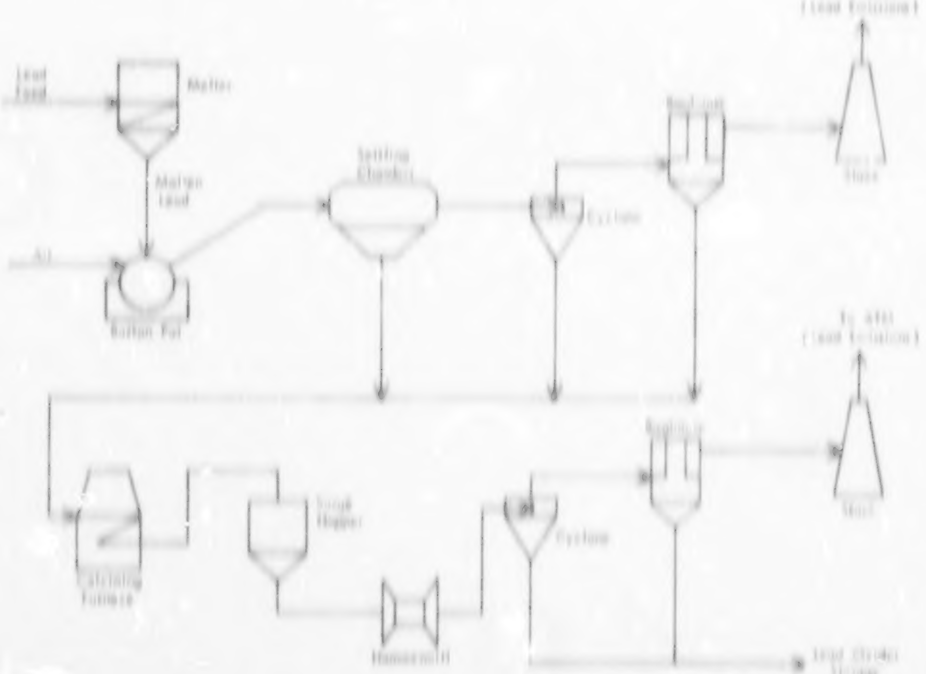
To Atm (Lead Emissions)
Lead Feed
Melter
Baghouse
Settling Chamber
Molten Lead
Cyclone
Stack
Air
Barton Pot
To Atm (Lead Emissions)
Baghouse
Surge Hopper
Cyclone
Stack
Calcining Furnace
Hammermill
Lead Oxide Storage

Figure 10-4. Schematic of Barton Pot and Calcining Furnace[1]

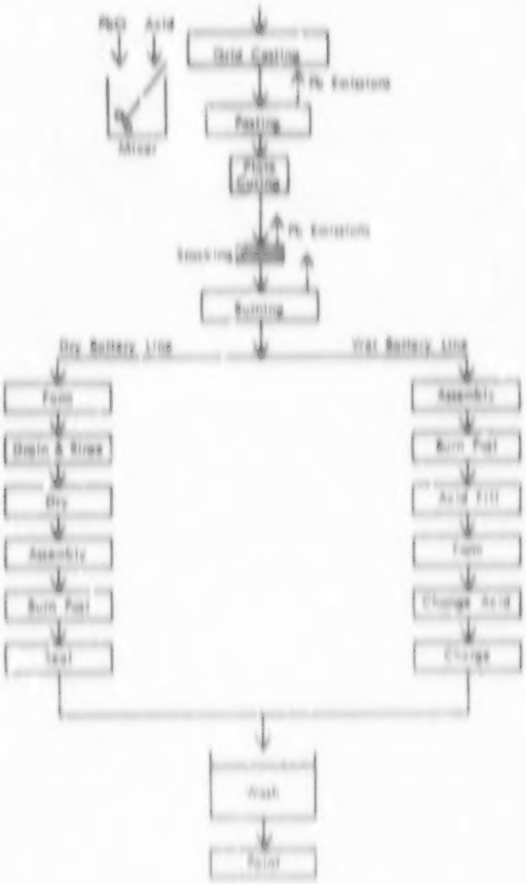
PbO
Acid
Mixer
Grid Casting
Pb Emissions
Pasting
Plate Curing
Pb Emissions
Stacking
Burning
Dry Battery Line
Wet Battery Line
Form
Drain & Rinse
Dry
Assembly
Burn Post
Seal
Assembly
Burn Post
Acid Fill
Form
Change Acid
Charge
Wash
Paint

Figure 10-5. Schematic for Lead Battery Production[1]

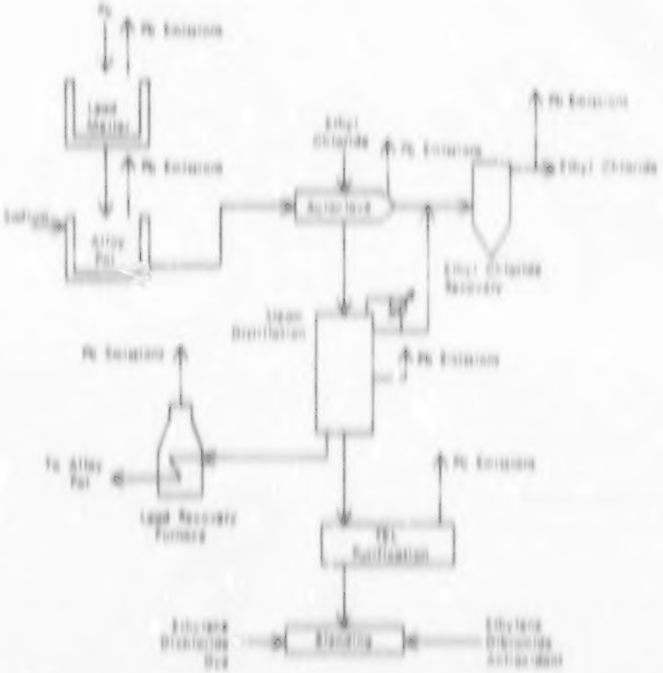
Pb
Pb Emissions
Lead Melter
Pb Emissions
Sodium
Alloy Pot
Ethyl Chloride
Pb Emissions
Autoclave
Pb Emissions
Ethyl Chloride
Ethyl Chloride Recovery
Steam Distillation
Pb Emissions
Pb Emissions
To Alloy Pot
Lead Recovery Furnace
Pb Emissions
TEL Purification
Ethylene Dichloride Dye
Blending
Ethylene Dibromide Antioxidant

Figure 10-6. Schematic for Lead Additive Production by Sodium-Lead Process[1]

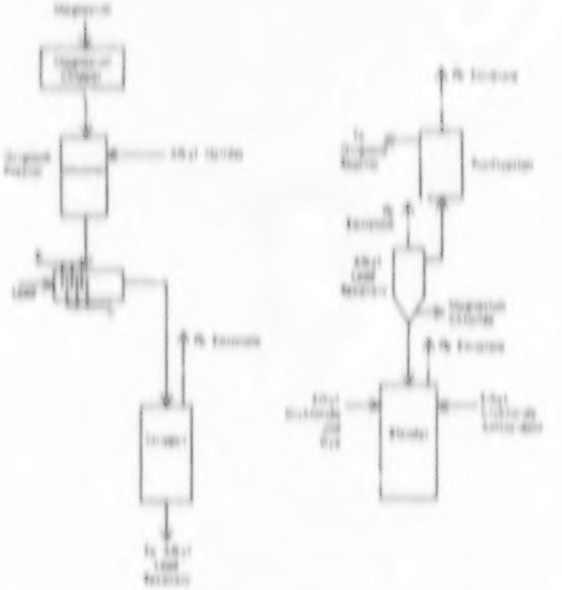

Figure 10-7. Schematic for Lead Additives Production by Electrolytic Process[1]

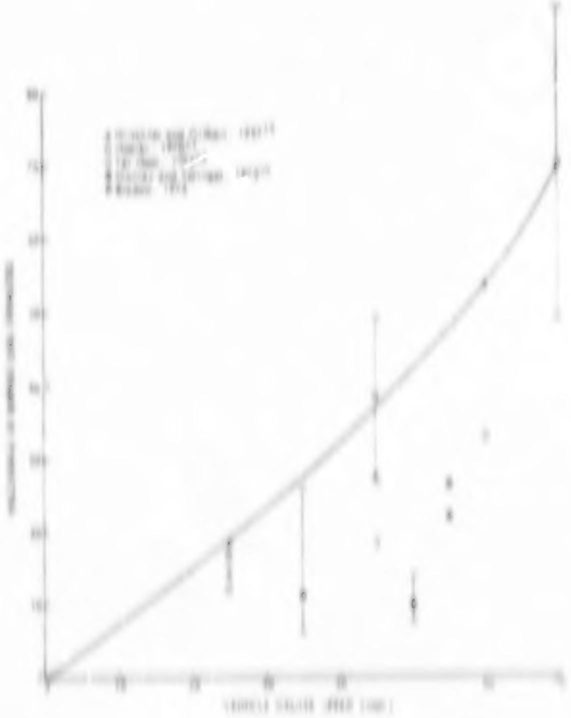

Figure 10-8. Percentage of Burned Lead Exhausted Versus Vehicle Cruise Speed[55]

APPENDIX G

FLUORIDE SPECIAL REPORT

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11. FLUORIDES

MINING[1]

The chief fluoride minerals are fluorspar, cryolite, and fluoroapatite. Fluorspar is a raw material used to produce hydrogen fluoride. The aluminum industry uses cryolite, and the fluoroapatite is mined for the phosphate.

The drilling, blasting, grinding, drying, and calcining of ore can produce fluoride emissions. No emission factors for these operations are presented because the emissions are relatively small and the solubility, which is related to the ecological impact, is low.

METALLURGICAL PROCESSING

Primary Aluminum Smelting[1-3]

Primary aluminum production is a major source of fluoride emissions. Particulate fluorides are emitted during the preliminary bauxite refining and the baking and reduction of the molten alumina metal. Most of the gaseous fluoride emissions come from the reduction process.

Aluminum is manufactured by the electrolytic reduction of alumina in a molten salt bath. There are three types of cells used today for the electrolysis: prebake, horizontal stud Soderberg, and vertical stud Soderberg. The anode configuration and type differs in the three cells but the basic process is the same.

The cell or "pot" contains a mixture of cryolite (Na_3AlF_6), alumina (Al_2O_3), and several other salts. The molten mass forms a mixture with two layers. The less dense upper layer consists of cryolite and additives, the lower of molten aluminum. The alumina oxidizes the anode forming aluminum, and is protected from the atmosphere by the cryolite layer.

The gaseous and particulate fluorides evolve from the fluoride used in the feed material. Although the pot lining absorbs 50% of the fluorides,[3] some fluorides are emitted. Emission factors for these sources are listed in Table 11-1.

Dry dust collection devices and/or wet scrubbers are used to control the particulate and gaseous fluoride emissions from the electrolytic cells. Dust from the handling of raw materials is a relatively small source of fluorides and is well controlled by dust collection devices.

Iron and Steel[2,4]

In the iron and steel industry, fluoride emissions are present mainly in the high temperature operations: iron ore pelletizing, iron ore sintering, and in the furnace operations. The pelletizing operation normally occurs at the mine sites and the sintering is usually done at the plant site. The furnace operations occur at the plant site in several configurations and combinations making any generalization difficult.

Pelletization is used mainly for taconite ores. The ore is ground, mixed, and formed into small balls. The balls are dryed, heated to bind the particles, and then cooled. Fluoride emissions occur during heating.

Sintering fuses fine material (iron ore and collected fumes) into an agglomerated mass suitable to use as blast furnace feed. The fine material is fused by heating, which also releases fluoride.

The furnace operations are described in Chapter 6. In all cases, the high temperatures cause fluoride to be emitted from the feed material. If hydrogen is available, gaseous fluoride is emitted as hydrogen fluoride; if not, calcium fluoride is emitted as dispersoid particulate.[2]

Only one United States iron and steel plant attempts to control fluoride emissions. The plant uses limestone in the feed material to the sintering plant and treats the flue gas with calcium hydroxide.[2] These alkaline substances react with the hydrogen fluoride to form particulates which can be collected by electrostatic precipitators. These procedures probably are not applicable to the industry as a whole.

Particulate control processes in the industry are incidental controls for fluorides. Wet scrubbers, electrostatic precipitators, and venturi scrubbers have been used for control of the particulates. Emission factors for the industry are given in Table 11-1.

Nonferrous Metals Smelting and Refining Industry[2]

The nonferrous metals smelting and refining industry produces copper, lead, and zinc. Most of the ores processed in the United States are sulfide mineral concentrates. The smelting and refining industry extracts the metals from these ores. Fluorides are associated with the gangue minerals and are emitted during the high-temperature steps. No fluoride emissions have been measured at smelter plants, but emission factors for copper, lead, and zinc plants determined by material balances are shown in Table 11-1.

Fluoride emissions in the industry are controlled only incidentally by sulfur dioxide control equipment.

PROCESSING AND UTILIZING FLUORIDES

Phosphate Rock Processing[1-3,5]

Phosphate rock is a raw material for the production of phosphoric acid, several types of phosphate fertilizers, and phosphorus. After the rock is removed from the ground, it is processed to remove impurities and moisture and then ground to increase reactivity. These process steps yield particulate emissions. The final products all require thermal and/or chemical processing which releases both gaseous and particulate fluorides.

Wet process phosphoric acid is produced by digesting phosphate rock with sulfuric acid. Particulate emissions include SiF_4 and CaF_2.[3] Gaseous HF is also emitted. Wet scrubbing systems are used universally for control.

The phosphoric acid produced by the wet process is used mainly for the production of ammonium phosphate fertilizers. There are several types of ammonium phosphate fertilizers, all made by reacting phosphoric acid, sulfuric acid, and anhydrous ammonia. The fertilizer can also have potash salts added. Phosphoric acid is the main source of fluoride emissions. These are controlled by two types of scrubber systems. One system is used to control the gaseous fluorides and ammonia emitted during the reaction process. The other controls particulates evolved during drying.

Triple superphosphate is made by combining phosphate rock and wet process phosphoric acid. The fertilizer can be produced in granular or pulverized forms, although the pulverized form is more common. Silicon tetrafluoride, some hydrogen fluoride, and some particulates will be emitted during triple superphosphate production. Wet scrubbers are usually used to remove the gaseous fluoride emissions.

Normal superphosphate is made by combining phosphate rock with sulfuric acid. After mixing, the material is allowed to solidify and cure. It is available ground or granulated. Fluoride emissions result from the acidulation, solidification, or denning and curing steps, as well as the original handling of the phosphate rock. Wet scrubbers are used to control the gaseous emissions from the acidulation and denning steps.

Elemental phosphorus is produced by smelting phosphate rock with silica and coke. Phosphorus is volatilized and collected in a gas stream coming from the furnace by a direct contact scrubber/condenser. Effluent gas from the original preparation of the rock is the main source of fluoride emissions. These emissions are controlled by spray towers or wet cyclone collectors.

The emission factors for these processes are given in Table 11-2.

Glass Manufacture[5]

Sand, limestone, soda ash, and broken glass scrap are melted together to produce glass. Other minor constituents are added to produce different varieties of glass. Soda-lime glass accounts for 90% of the U.S. production. Fluoride makes the glass opaque, consequently the fluoride content of the raw materials is minimized. The only exception is during the manufacture of opal glass where fluoride is deliberately added to make a translucent glass.

The fluoride emissions from glass manufacturing are dependent upon the fluoride content in the feed material. The emission factor for glass melting equals 4 F, pounds per ton of glass produced, where F is the percentage of fluoride input to the furnace. The average content of fluoride in the raw material used for opal glass manufacture is 10%.

Both particulates and gases are emitted during production. Wet cyclone scrubbers are effective for the gases but are not as efficient as a baghouse for removing the fine particulates emitted.

Frit Smelting[1,5]

Frits are coatings used to protect or decorate metal, glass, and pottery. Frit is prepared by fusing together a mixture of borax, feldspar, sodium fluoride or fluorspar, soda ash, zinc oxide, litharge, silica, boric acid, and zircon. This molten mass is quenched with air or water which causes the mass to solidify rapidly and shatter into the frit. The frit is dried and ground into finer particles. The frit coatings are applied as slip, a mixture of frit and clay in a water suspension.

Both particulate and gaseous fluoride emissions are emitted during the frit smelting. Total fluoride frit emissions for a rotary furnace are given in Table 11-2. Baghouses and venturi scrubbers are used for control.

HF Alkylation Processes[2]

High octane petroleum products are formed by alkylation. This process reacts isoparaffins with olefins and olefin mixtures to form the high octane products. Hydrofluoric acid is used in some alkylation processes as a catalyst.

Hydrogen fluoride can be recovered in some of the processes by using defluorinating towers packed with alumina. The HF reacts with the alumina and forms AlF_3, a solid which is easily recovered. This system is used only for HF emitted in the process stream; other sources of HF are not controlled. The total emission factor for the alkylation process is given in Table 11-2.

HF Production[2,5,6]

Hydrogen fluoride is produced by mixing fluorospar and sulfuric acid in a furnace. The hydrogen fluoride gas that evolves from the furnace reaction is treated and dissolved in a strong acid solution. Anhydrous hydrofluoric acid is formed by distilling 80% hydrofluoric acid and condensing the gaseous HF which has been driven off. Soluble fluoride emission factors are given in Table 11-2.

The economic benefits of efficient control (the evolved HF is the product and the pollutant) and the large quantity and concentration of the toxic fluorides have combined to make the industry use the most efficient control systems available. Water scrubbers and/or caustic scrubbers are integrated within the production system for control.

Heavy Clay Products[2]

Structural heavy clay products, e.g., brick, pipe and tile, use over 20 million tons of clay annually. The fluorides present in the clay are volatilized during the product firing and emitted exclusively as hydrogen fluoride.

A typical brick production plant emits 0.87 lb of soluble fluorides per ton of brick produced. It was assumed that these emissions were exclusively hydrogen fluoride (Table 11-2). Emissions can be controlled by cleaning the effluent gas with a spray scrubber, although less than 1% of the heavy clay plants currently use this control procedure.

Expanded Clay Aggregates[2]

Expanded clay aggregate pellets are used as a replacement for gravel in the production of high strength concrete. After formation of the pellets from a mixture of clay, oil, and water, the pellets are fired in a sinter machine, then coated and stored.

Hydrogen fluoride is evolved from the calcium fluoride in the sinter machine, and the crusher emits particulate calcium fluoride. The total process fluoride emission factor is given in Table 11-2.

Very few of the current producers of expanded clay aggregates use any control equipment. Those producers use spray scrubbers or baghouses.

Cement Manufacture[1,5]

Cement manufacturing processes are described in Chapter 4. Fluoride is present in the major raw materials as calcium fluoride. Emissions from both the wet and dry process occur during calcination when hydrogen fluoride is evolved and during the handling of the raw materials and product when calcium fluoride is emitted.[1]

The hydrogen fluoride gas evolved during calcination is usually adsorbed by alkaline particulate matter in the flue gas from the furnace. Cyclone filters and baghouses collect the particulate matter with the fluorides that have reacted with them. Thus the particulate control effectively reduces the fluoride emission. The only quantitative data available is for soluble fluorides (Table 11-2).

Other Industries

The manufacture of fluorine and fluorocarbon chemicals is not a significant source of fluoride emissions.[2] Since fluorine is a portion of the raw material and the product, it is economically feasible to use advanced control systems. The fluoride emissions also constitute a health hazard, so controls are needed to avoid legal action. No emission factor data for these operations are available.

Other industries that are minor sources of fluoride emissions include uranium fluoride production, aluminum anodizing, and beryllium production. No emission factor information is available for these operations.

FUEL COMBUSTION

Coal[2,7,8]

Coal-burning electric power plants emit most of the fluorides associated with coal combustion. This industry is the largest consumer of coal in the country. The average content of fluoride in bituminous coal, usually as fluorspar or fluorapatite, is 0.008%.[7]

It has been shown that about half the contained fluoride is emitted as gaseous HF, SiF_4 and particulate matter during coal combustion.[8] The emission factors for coal combustion are shown in Table 11-3.

Generally, pollution control at power plants is limited to fly ash collecting systems. A few facilities use alkaline injection and/or scrubbing systems to control SO_2 which would also limit hydrogen fluoride emissions. The actual effectiveness of fluoride control by these methods is not known at this time.[2]

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Table 11-2 EMISSION FACTORS FOR FLUORIDE EMISSIONS FROM METALLURGICAL PROCESSES^a

Source	Gaseous fluoride (HF) emission factors		Particulate fluoride (F) emission factors		Emission factor symbol^b	Reference
	kg/10^3 kg	lb/ton	kg/10^3 kg	lb/ton		
Bauxite grinding, uncontrolled^c	Neg	Neg	NA^d	NA	[illegible]	5
Calcining of aluminum hydroxide, uncontrolled	Neg	Neg	NA	NA	[illegible]	5
Primary aluminum production						
Anode baking furnace, uncontrolled	0.47	0.93	Neg	Neg	[illegible]	5
Spray tower^e	0.0186	0.0372	Neg	Neg	[illegible]	5
Dry electrostatic precipitator	0.47	0.93	Neg	Neg	[illegible]	5
Self-induced spray	0.0186	0.0372	Neg	Neg	[illegible]	5
Prebaked reduction cell, uncontrolled^f	12.25	24.5	10.2	20.4	[illegible]	5
	(6.9–17.4)	(13.8–34.8)	(4.7–17.8)	(9.4–35.5)	[illegible]	5
Multiple cyclone	12.25	24.5	2.15	4.29	[illegible]	5
Fluid-bed dry scrubber	0.124	0.247	0.254	0.507	[illegible]	5
Coated filter dry scrubber	0.99–2.97	1.98–5.94	0.244	0.488	[illegible]	5
Dry electrostatic precipitator	12.25	24.5	0.249–1.12	0.498–2.24	[illegible]	5
Spray tower	0.247–1.26	0.494–2.52	2.44	4.88	[illegible]	5
Floating-bed scrubber	0.247	0.494	2.44	4.88	[illegible]	5
Chamber scrubber	1.48	2.96	3.53	7.06	[illegible]	5
Vertical flow packed bed	4.2	8.4	3.53	7.06	[illegible]	5
Dry alumina adsorption	0.247	0.494	0.244	0.488	[illegible]	5
Horizontal-stud Soderberg cell, uncontrolled^f	13.3	26.6	7.8	15.6	[illegible]	5
	(11.6–14.1)	(23.2–28.2)	(7.2–8.1)	(14.4–16.2)	[illegible]	5
Spray tower	0.95–1.195	1.90–2.39	1.28–2.885	2.55–5.77	[illegible]	5
Floating-bed scrubber	0.266	0.532	0.1725	0.345	[illegible]	5
Wet electrostatic precipitator	13.3	26.6	0.585	1.17	[illegible]	5
Vertical-stud Soderberg cell, uncontrolled^f	15.2	30.4	5.3	10.6	[illegible]	5
	(14.9–17.5)	(29.8–35.0)	(2.8–17.7)	(5.6–35.3)	[illegible]	5
Spray tower	0.152	0.304	1.025	2.05	[illegible]	5
Self-induced spray	0.152	0.304	NA	NA	[illegible]	5
Venturi scrubber	0.152	0.304	0.237	0.474	[illegible]	5
Wet electrostatic precipitator	15.2	30.4	0.053–0.73	0.106–1.46	[illegible]	5
Multiple cyclones	15.2	30.4	2.65–3.18	5.30–6.36	[illegible]	5
Dry alumina adsorption	0.304	0.608	0.116	0.232	[illegible]	5

Table 11.1 (continued)

Source	Gaseous fluoride (HF) emission factors kg/10³ kg	Gaseous fluoride (HF) emission factors lb/ton	Particulate fluoride (F) emission factors kg/10³ kg	Particulate fluoride (F) emission factors lb/ton	Emission factor rating[b]	Reference
Materials handling, uncontrolled	Neg	Neg	[illegible]	[illegible]	[illegible]	5
Spray tower	Neg	Neg	[illegible]	[illegible]	[illegible]	5
Floating-bed scrubber	Neg	Neg	[illegible]	[illegible]	[illegible]	5
Quench tower and spray screen	Neg	Neg	[illegible]	[illegible]	[illegible]	5
Electrostatic precipitator	Neg	Neg	[illegible]	[illegible]	[illegible]	5
Iron and steel mills						
Open hearth						
No oxygen lance, uncontrolled	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	5
Venturi scrubber	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	5
Electrostatic precipitator	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	5
Oxygen lance, uncontrolled	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	5
Venturi scrubber	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	5
Electrostatic precipitator	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	5
Basic oxygen, uncontrolled	Neg	Neg	[illegible]	[illegible]	[illegible]	5
Venturi scrubber	—	—	[illegible]	[illegible]	[illegible]	5
Electrostatic precipitator	—	—	[illegible]	[illegible]	[illegible]	5
Spray chamber	—	—	[illegible]	[illegible]	[illegible]	5
Electric arc						
No oxygen lance, uncontrolled	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	5
Venturi scrubber	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	5
Electrostatic precipitator	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	5
Baghouse	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	5
Oxygen lance, uncontrolled	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	5
Venturi scrubber	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	5
Electrostatic precipitator	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	5
Baghouse	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	5
Copper smelters, uncontrolled	0.35	0.70	[illegible]	[illegible]	[illegible]	2
Zinc smelters, uncontrolled	0.23	0.46	[illegible]	[illegible]	[illegible]	2
Lead smelters, uncontrolled	0.17	0.34	[illegible]	[illegible]	[illegible]	2

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[a] Unless otherwise stated, uncontrolled emission factors are expressed as pounds F emitted per ton of metal produced.

[b] Defined in Table 1-1.

[c] Units are pounds per ton (kilograms per metric ton) of bauxite processed.

[d] No information available.

[e] Controlled emissions are based on industrial average observed collection efficiencies.

[f] Numbers in parentheses are ranges.

Table 11-2. [illegible] FACTORS FOR [illegible] [illegible] [illegible] [illegible] [illegible] SOURCES[illegible]

Source	Fluoride[a] (F) emission factors	Gaseous fluoride (HF) emission factors	Emission factor rating[b]	Reference
Phosphate rock processing				
Wet process phosphoric acid				
Reactor	[illegible] kg/Mt ([illegible] lb/ton) of phosphate rock processed	—	[illegible]	[illegible]
Gypsum pond	[illegible] kg/hectare/day[c] ([illegible] lb/acre/day[c])	—	[illegible]	[illegible]
Condenser	[illegible] kg/Mt ([illegible] lb/ton) of phosphate rock processed	—	[illegible]	[illegible]
Diammonium phosphate	[illegible] kg/Mt[d] ([illegible] lb/ton[d]) of P_2O_5 in product	—	[illegible]	[illegible]
Triple superphosphate	[illegible] kg/Mt[d] ([illegible] lb/ton[d]) of P_2O_5 in product	—	[illegible]	[illegible]
Normal superphosphate	[illegible] kg/Mt[d] ([illegible] lb/ton[d]) of P_2O_5 in product	—	[illegible]	[illegible]
Electrothermal phosphorus	[illegible] kg/Mt[d] ([illegible] lb/ton[d]) of P_2O_5 in feed	—	[illegible]	[illegible]
Glass manufacture	[illegible] kg/Mt[e] ([illegible] lb/ton[e]) of glass produced	—	[illegible]	[illegible]
[illegible] melting ([illegible] furnace)	[illegible] kg/Mt ([illegible] lb/ton) weight of charge	—	[illegible]	[illegible]
HF alkylation processes	[illegible] kg/barrel[f] ([illegible] lb/barrel[f]) of alkylate produced	[illegible] kg/barrel ([illegible] lb/barrel) of alkylate produced	[illegible]	[illegible]
HF production	[illegible] kg/Mt[d] ([illegible] lb/ton[d]) of HF produced	—	[illegible]	[illegible]
Heavy clay products	[illegible] kg/Mt[e] ([illegible] lb/ton[e]) of material produced	[illegible] kg/Mt ([illegible] lb/ton) of material produced	[illegible]	[illegible]
Expanded clay aggregate	[illegible] kg/Mt[d] ([illegible] lb/ton[d]) of aggregate produced	—	[illegible]	[illegible]
Cement production	[illegible] kg/Mt[d] ([illegible] lb/ton[d]) of cement produced	—	[illegible]	[illegible]

[a] Unless otherwise stated, uncontrolled emission factors are expressed as pounds of total F emitted per unit [illegible].

[b] Defined in Table 1-1.

[c] Approximately [illegible] acre ([illegible] hectare) is required to produce 1 ton of P_2O_5 daily.[illegible]

[d] Fluoride emitted as "soluble" fluoride where soluble fluorides are defined as those fluorides with significantly greater solubility than calcium fluoride.[illegible]

[e] F is equal to the percentage of fluoride in the feed material.

[f] The soluble fluorides were emitted "exclusively" as gaseous hydrogen fluoride.[illegible]

Table 11-3. EMISSION FACTOR FOR FLUORIDE EMISSIONS FROM COAL COMBUSTION[a]

Source	Fluoride (F) emission factor lb/ton	Fluoride (F) emission factor $kg/10^3$ kg	Emission factor symbol[b]	Reference
Coal combustion	0.16	0.08	MB	2

[a] Uncontrolled emission factors are expressed as pounds F emitted per ton of coal burned.

[b] Defined in Table 1-1.

APPENDIX D

HYDROGEN CHLORINE/CHLORIDE SPECIAL REPORT

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12. CHLORINE/HYDROGEN CHLORIDE

CHLORINE

Chlorine emissions result primarily from anthropogenic sources, there being no significant natural sources known. The majority of the chlorine emissions result from the production and handling of chlorine. Emission factors for chlorine are summarized in Table 12-1. The following text provides background information on the development of these factors.

Primary Production Industries[1-3]

About 97 percent of primary chlorine production utilizes electrolysis of alkali chloride-water solutions through the diaphragm cell and mercury cell processes.[1,2] In the diaphragm cell process, chlorine gas is liberated at the anode, cooled to remove water, and then dried by contact with sulfuric acid. The chlorine gas may then be liquefied or compressed for use or storage. The mercury cell process uses mercury as the cathode and liberates chlorine gas at the anode. The chlorine is cooled, dried, and processed for use or storage.

Within these processes, sources of chlorine emissions are (a) blow gas resulting from the liquefaction of chlorine, (b) removal of water vapor from the chlorine gas stream, (c) air blowing of depleted brine in mercury cell plants, and (d) emergency venting.

The blow gas from the liquefaction of chlorine contains 20 to 100 pounds per ton of chlorine in the diaphragm cell process and 40 to 160 pounds per ton of chlorine in the mercury cell process.[1] Control of chlorine emissions may be obtained with either water absorbers or caustic or lime scrubbers.[1]

The process for removal of water vapor from the chlorine product gas stream is also a source of chlorine emissions. In cooling the chlorine gas stream sufficiently to condense the water, the loss of chlorine ranges from 4 to 12 pounds per ton of chlorine liquefied.[1] The water may be treated by absorption or stripping to reduce the chlorine emissions to 0.1 to 0.2 pounds per ton chlorine liquefied (10 ppm concentration).[1]

In mercury cell plants, recycled brine becomes saturated with chlorine after use, and the depleted brine is air-blown to reduce the chlorine content. The chlorine in the air stream is present at low concentration and can be successfully controlled by absorption or stripping.

Emergency venting is an intermittent source of chlorine. This source, as well as sources relating to valve and packing failure, can be controlled by venting to control equipment. Estimation of emission factors is not possible for this source.

Another process, the Downs cell, uses electrolysis to liberate chlorine and molten sodium from a sodium chloride-calcium chloride mixture at 550°C. The chlorine is removed from the cell, cooled, and handled in the same manner as in the diaphragm and mercury cells. Similar chlorine emissions and controls are found for this process.

Handling and Utilizing Chlorine

Storage and Transport[1]

The handling and transportation of chlorine results in emissions of chlorine to the atmosphere. The primary sources of emissions are (a) large containers used to ship and store chlorine, and (b) air used to compress and transport chlorine. Storage tank vents can release 1,200 pounds per 100 tons of chlorine stored (uncontrolled). Large containers and tank cars contain residual chlorine gas after unloading; this can result in 450 pounds emitted per 100 tons stored (uncontrolled). These emissions are prevented by vacuuming the containers. Chlorine may be transferred or compressed using air padding to pressurize and remove liquid chlorine. The air will pick up some chlorine. The chlorine lost with this air can be from 1.1 to 60 pounds per ton of chlorine liquified (average 17 lb).[1] This source of emissions can be adequately controlled with scrubbers.

Synthesis of and Reaction with Organic Chemicals[1]

In 1970, 23 organic processes used approximately 67 percent of the chlorine produced in the United States. Of these processes, 11 generated no significant chlorine emissions, five had emissions less than 0.002 pound per ton of product, and two had emissions of 20 pounds per ton of product.

The latter two processes are the thermal chlorination of propane to carbon tetrachloride, and thermal chlorination of propane to perchloroethylene. The purge stream which removes impurities in the raw materials is the source of the chlorine emissions.

The use of chlorine in the inorganic industry does not result in significant emissions. Because of the hazardous nature of the products of these inorganic processes, emission controls have been well established within the industry.

Glass Manufacturing[4,5]

The major source of chlorine emissions in the glass industry is the melting furnace. Chlorine has been measured in the exhaust gas from melting furnaces[5] and does not appear to vary in concentration from flint or amber glass. Due to the high temperatures in the exhaust gas, chlorine apparently reacts to form HCl. Partial control of chlorine may be realized by utilization of control devices designed for other emissions. Concentrations of chlorine in melting furnace exhaust gas range from 4.1 to 4.9 ppm, but emission factors cannot be estimated from existing data.[5]

Pulp and Paper Bleaching[1]

The pulp and paper industry uses hypochlorite and chlorine dioxide to bleach paper pulp and to purify the dissolving pulps to obtain high concentrations of alpha-cellulose. These processes can result in the release of chlorine, but most of the chlorine emissions are controlled.

Brick Manufacturing[6]

The drying of bricks in kilns is an emission source of chlorine. Emission factors given in Table 12-1 represent extreme emission cases. The extent of controls on this source is not known.

Water and Wastewater Treatment[1]

Chlorine is used to destroy microorganisms in water and wastewater treatment facilities. The release of chlorine from these sources does not constitute a significant environmental problem.

Fuel Combustion[1,5,7,8]

The combustion of coal and oil releases the chlorine bound in these fuels. One of the primary products of combustion is hydrogen chloride gas or hydrochloric acid. To alleviate the problem of apportioning the original chlorine to the various compounds it may react to form, emissions are stated as chlorine. In the literature, this is a common method of reporting chlorine related combustion emissions.

Coal may contain from 0 to 0.46 percent chlorine, with an average of 0.128 percent.[1] Ninety-three percent to 98.5 percent of the chlorine generated exits from the stack. The quantity of coal burned in the United States make this a significant source of chlorine. Emission factors are given in Table 12-1.

The burning of fuel oil can also result in chlorine emissions, but emissions are considered to be negligible. An estimated 500 pounds of chlorine is emitted daily per 100,000 persons due to domestic heating by oil.[7]

Control of chlorine from the combustion of coal or oil can be achieved through scrubbers which will also control sulfur dioxide.

HYDROGEN CHLORIDE

Nearly all hydrogen chloride emissions to the atmosphere result from anthropogenic sources. The only known significant natural source of hydrogen chloride is volcanic eruption. Hydrogen chloride emission factors are presented in Table 12-2.

Primary Production Industries[1]

Approximately 90 percent of the hydrogen chloride produced in the U.S. is obtained as a by-product of chlorination of organic compounds.[1] By-product hydrogen chlorine is produced in the manufacture of chlorinated benzene, chlorinated toluenes, vinyl chlorides, chloroform, chlorinated paraffins and many other compounds. The emissions of hydrogen chloride from these processes vary with the type of process and equipment used. Emission concentrations of 0.5 percent by volume of the tail gas are common for these processes.[1] Reported emission factors are given in Table 12-2.

The primary process used to create high purity hydrogen chloride is the synthesis process. The synthesis process is a process in which chlorine and hydrogen are burned to produce high purity gas. Process emissions vary with raw materials and control equipment, but emissions are slight. Emission factors are given in Table 12-2.

The manufacture of hydrogen chloride by the Mannheim and Hargreaves processes results in greater emissions than from the other two sources (by-products and synthesis process). Limited data for emissions from the Mannheim process plants are available, and there are none for the Hargreaves process plants.

Handling and Utilizing Hydrogen Chloride[1]

Hydrogen chloride emissions from its handling and storage have not been studied. No emission factors exist for these operations.

Hydrogen chloride emissions are present in automobile exhaust. The use of antiknock compounds introduces chlorine into the exhaust system with the possibility of the formation of hydrogen chloride. No data are available on the quantity of hydrogen chloride emitted.

Solid Waste Incineration

The burning of insulated wire cover results in hydrogen chloride emissions. Emission factors cannot be assigned due to the lack of information on burning procedures.

The incineration of automobile bodies results in hydrogen chloride emissions, but emission factors have not been developed because of the lack of information on burning procedures.

Emissions stemming from the incineration of municipal refuse have been studied, and the hydrogen chloride emissions can be estimated. Hydrogen chloride emissions result primarily from the burning of polyvinyl chloride and polyvinylidene chloride. Approximately 3 percent of municipal refuse is plastic material, but most (87 percent) of this plastic does not contain chlorine. The chlorine content of typical municipal refuse has been estimated to be 0.5 percent. Emission factors for incineration are given in Table 12-2.

Other Industrial/Agricultural Sources[5,9,10]

Hydrogen chloride is released by some metallurgical processes. Emission factors for aluminum batch processing and hot strip pickling are given in Table 12-2.

The surface of steel is cleaned or "pickled" in a bath of sulfuric or hydrochloric acid. The prickling action removes the surface oxide on the steel. The pickling bath is a source of hydrogen chloride emissions.[9]

Chlorine gas is used to reduce the magnesium content of aluminum alloys. The chlorine is bubbled through the molten aluminum. Some of the chlorine escapes as hydrogen chloride. This source is generally well controlled, but hydrogen chloride escapes when the magnesium chloride is skimmed off.[10]

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Table 12-1. EMISSION FACTORS FOR CHLORINE

Source[a]	Emission factor[b] kg/10³ kg	Emission factor[b] lb/ton	Emission factor symbol[c]	Reference
Chlor-alkali				
Diaphragm cell[d]	15-50	30-100	UK	1
Diaphragm cell[d,e]	0.25	0.5	UK	3
Mercury cell[d]	20-80	40-160	UK	1
Mercury cell[d,e]	0.4	0.8	UK	3
Air blowing of mercury cell brine[d]	2.5	5.0	UK	1
Air blowing of mercury cell brine[d,e]	0.12	0.25	UK	3
Condensed water losses	0.10	0.20	UK	1
Loading of chlorine				
Storage tank vents[d]	6.0	12.0	UK	1
Storage tank vents[d,e]	0.12	0.25	UK	3
Tank car vents[d]	8.5	17.0	UK	4
Tank car vents[d,e]	0.11	0.21	UK	3
Chlorine in air padded to compress				
Cl_2	0.55-30	1.1-60	UK	1
Thermal chlorination of propane to:				
CCl_4	10	20	UK	1
Perchloroethylene	10	20	UK	1
Pulp bleaching	9-21	18-42	UK	5
Brick manufacturing[e]	0.12-0.5	0.23-1.0	UK	6
Fuel combustion				
Coal	2	4	UK	8
Oil	0.07	0.13	UK	8

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a Uncontrolled unless otherwise specified.

b Emission factor expressed as mass of chlorine emissions per mass unit of product.

c Defined in Table 1-1.

d Total process emissions.

e Controlled emissions.

Table 12-2. EMISSION FACTORS FOR HYDROGEN CHLORIDE

Source[a]	Emission factor[b] kg/10^3 kg	Emission factor[b] lb/ton	Emission factor symbol[c]	Reference
HCl manufacturing				
By-product	0-6.5	0-13		
Synthesis process	0-13	0-27 (per ton of 100% acid)	UK	5
HCl manufacturing[d]				
By-product	0.25	0.5		
Synthesis process	0.05	0.1 (per ton of 100% acid)	UK	1
Chlorination of carbon disulfide	0.0001	0.0002	UK	1
Chlorination of ethylene	0.0005	0.001	UK	1
Hydrochlorination of ethylene	0.0005	0.001	UK	1
Chlorohydrination of alychloride	0.001	0.002	UK	1
Chlorohydrination of propylene	0.001	0.002	UK	1
Open burning	1.0	2.0	UK	5
On-site incineration	1.28	2.55	UK	5
Conical burner	1.0	2.0	UK	5
Municipal incineration	0.82	1.65	UK	5
Aluminum batch processing	0.06-1.5	0.12-3.1 (lb/hr/13.5 T batch)		5
Hot strip pickling	0.007-0.047	0.014-0.094 (ton of steel)	5	

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a Uncontrolled unless otherwise specified.

b Emission factor expressed as mass of hydrogen chloride emissions per mass unit of product, unless otherwise specified.

c Defined in Table 1-1.

d Controlled emissions.

APPENDIX E

FORMAT FOR EMISSIONS INVENTORY EVALUATION

HATREMS EMISSION INVENTORY EVALUATION
BY POLLUTANT/SCC

Pollutant Code: ________ SCC No. ____________________
Pollutant: ____________ SCC ____________________
____
____
Date: ________________ ____________________
By: __________________

Emission Factor Input

Basis: ☐ Coded HATREMS Data ☐ Non-HATREMS Data
Emission Factor ______________ Units ____________________
Default Multiplier ____________ Units ____________________

Control Efficiency Multiplier ____________________
NEDS Pollutant Flag _____ Type ____________________
NEDS Pollutant Control Efficiency (%) Unknown Estimated ____%
Data Entered into HATREMS ____________________
Source Origin Code ______________ Type ____________________
Emission Factor Reliability ________ Type ____________________
Comments ____
____

Process Input

Basis: ☐ NEDS Data ☐ Non-NEDS Data
Annual SCC Process Throughput Rate ____________________
Units ____
Area: ☐ Plant ☐ County ☐ AQCR ☐ State ☐ National
Reference ____

Emissions Output Comparison

HATREMS/NEDS Emissions ____________________ tons/year

Calculated Emissions* ____________________ tons/year
Basis:
☐ HATREMS Emission Factors/Non-NEDS Process Data
☐ Non-HATREMS Emission Factors/Non-NEDS Process Data
☐ Non-HATREMS Emission Factors/NEDS Process Data

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* Emissions (ton/year) = Emission Factor (lb/SCC unit · DM unit)

× Default Multiplier (DM units) × $\frac{\text{Control Efficiency (\%)}}{100}$

× Annual Process Throughput Rate (SCC units/year) × $\frac{1 \text{ ton}}{2{,}000 \text{ lb}}$

HATREMS EMISSION INVENTORY EVALUATION
BY POLLUTANT/SCC

Pollutant Code: A7128

Pollutant: Lead

Date: 5/9/77

By: R. Bohn

SCC No. 30300502

SCC Industrial Process - Primary Metals - Copper Smelter - Roasting

Emission Factor Input

Basis: ☒ Coded HATREMS Data ☐ Non-HATREMS Data

Emission Factor 2.3 Units Tons concentrated ore

Default Multiplier 0.3 Units Percentage lead in concentrate ore

Control Efficiency Multiplier 100.0

NEDS Pollutant Flag 1 Type Particulate

NEDS Pollutant Control Efficiency (%) (Unknown) Estimated ____ %

Date Entered into HATREMS 11/1976

Source Origin Code D Type Other reference

Emission Factor Reliability 4 Type Average

Comments Based on Bibliography Reference 85 data, HATREMS Final Report

Process Input

Basis: ☐ NEDS Data ☒ Non-NEDS Data

Annual SCC Process Throughput Rate 4,400,000 (1975)

Units Tons of concentrated ore per year

Area: ☐ Plant ☐ County ☐ AQCR ☐ State ☒ National

Reference

Emissions Output Comparison

HATREMS/NEDS Emissions ____________ tons/year

Calculated Emissions* 1,518 (uncontrolled) tons/year

Basis:
- ☒ HATREMS Emission Factors/Non-NEDS Process Data
- ☐ Non-HATREMS Emission Factors/Non-NEDS Process Data
- ☐ Non-HATREMS Emission Factors/NEDS Process Data

---

* Emissions (ton/year) = Emission Factor (lb/SCC unit - DM unit)

$$\times \text{ Default Multiplier (DM units)} \times \frac{\text{Control Efficiency (\%)}}{100}$$

$$\times \text{ Annual Process Throughput Rate (SCC units/year)} \times \frac{1 \text{ ton}}{2{,}000 \text{ lb}}$$